BACKGROUND GRAPHICS: A DECISION-MAKING HINDRANCE OR ENHANCEMENT ?

THESIS

David L. Peeler, Jr., 1 Lt, USAF

AFIT/GCA/LAS/96S-12

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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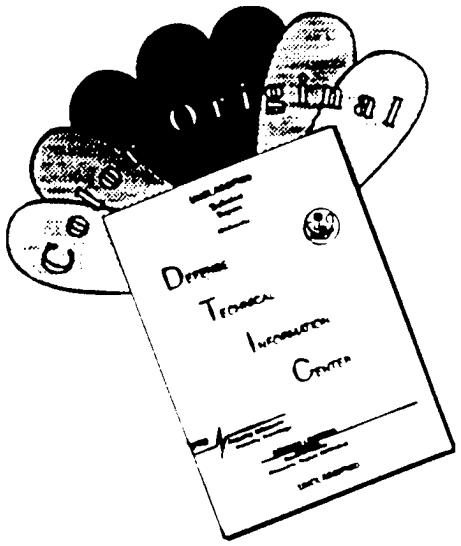

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THESIS

Presented to the Faculty of the Graduate School of

Logistics and Acquisition Management of the

Air Force Institute of Technology

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In Partial Fulfillment of the

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Master of Science in Cost Analysis

David L. Peeler, Jr., B.A., B.S.

1Lt, USAF

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The subject matter of this thesis is dependent upon the use of color. The graphs utilized in this study contain color. The graphs treated with background graphics have their background area filled-in with color and color images. Some reproductions of this work will not include color. If the reader possesses a Defense Technical Information Center (DTIC) or other noncolor reproduction of this thesis, a color copy can be obtained by contacting Dr. David S. Christensen at AFIT/LAS, Air Force Institute of Technology, Building 641, 2750 P Street, Wright-Patterson AFB OH 45433-7765.

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David L. Peeler, Jr.

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Abstract

This thesis investigated the influence, if any, of background graphics on the decision-making process. Specifically the hypotheses tested the affect of background graphics on a decision-makers accuracy and confidence. A literature review revealed an abundance of graphic research but little reference to the use of background graphics. Using guidelines previously created for high-integrity graphics, a timed 2 x 2 factorial experimental design was developed to compare the responses to both traditional graphics and those treated with background graphics. One hundred forty-seven subjects, all employees of the United States Air Force or defense contractors were involved in the experiments. The Kruskal-Wallis test was employed to test the hypotheses. The analysis of the test results indicate that background graphics neither affect decision accuracy nor the confidence a decision-maker places in a decision. It was also determined that gender and training have no affect on accuracy and confidence.

BACKGROUND GRAPHICS: A DECISION-MAKING HINDRANCE OR ENHANCEMENT ?

I. Introduction

General Issue

The utilization of background graphics in professional presentations has proliferated over the last decade. Background graphics are defined as any pictures or color schemes that fill in the background area behind the essential information presented to a decision-maker. The capability to place background graphics on presentations is now available to anyone with access to a personal computer (PC). With the advanced computer technology and the accompanying increase in access to PCs, anyone with a point of view to convey can utilize background graphics to attempt to influence decision-makers. Background graphics are becoming more widely used for the purpose of influencing decision-makers.

The format in which a person presents the ideas being advocated is crucial to the decision-making process. "Regardless of whom you are making a presentation to, the purpose of a presentation isn't to make your point, but to sell an audience on your point of view!" (Needleman, 1993: 15). The particular point of view in question is the presenter's product. If the product is obscured by the packaging, there may not be a sell; *i.e. the decision-maker may be misled or distracted.*

The outcome of a presentation depends upon two main ingredients: the believability of the presentation, and the accurate extraction of information by the decision-maker. To guarantee success, "you not only have to understand what information you need to present, but also the best way to present it so that it reinforces your final goal, not obscures it" (15). Therefore, the presenter should choose appropriate background graphics, if any, to capture the decision-maker's attention without affecting the outcome (decision) indicated by the information.

Specific Problem

The marketplace is suffused with claims about the power of graphics to enhance both the appeal of presentations and a viewer's ability to use them. Specific claims have been made that by using background graphics, "you can be more effective in getting your point across" (Microsoft, 1994: 1). Researchers are split on the issue of graphics; some contend that graphics do indeed enhance the decision-making process (Horton, 1991: 12), while others reject the idea (Tufte, 1983: 107 & 121). A third group of researchers maintain that "no empirical evidence exists to support or refute this claim" (Jarvenpaa, 1986: 3). The studies involved in reaching these conclusions used experiments that presented information to decision-makers in various forms, but primarily in graphic or tabular formats. These formats are illustrated in Table 1 and Figure 1.

Table 1. Tabular Presentation of Data

$(000)	1990	1991	1992	1993	1994	1995
In-house Net Costs	$125.117	$122.179	$124.938	$128.798	$132.112	$136.875
Contractor Bids	$124.000	$124.000	$124.000	$125.000	$130.000	$130.000

A table can be rather short and narrow, as represented above in Table 1, or extremely lengthy. Some tables contain thousands of entries and take up scores of pages. While not all tables are massive in their bulk, many are so large as to be incomprehensible to many potential users. Often such cases of excessive tabular bulk can be reduced to an easily-read graphic. Thus, graphics provide a format for the utilization of information previously underutilized, primarily due to the cumbersome size of the information's format.

Whereas graphics literature is full of examples of comparisons between tables and graphs, no studies were found that examined the use of background in conjunction with graphic presentation of data. Figure 1 below is an example of how graphics can be used to convey informative data.

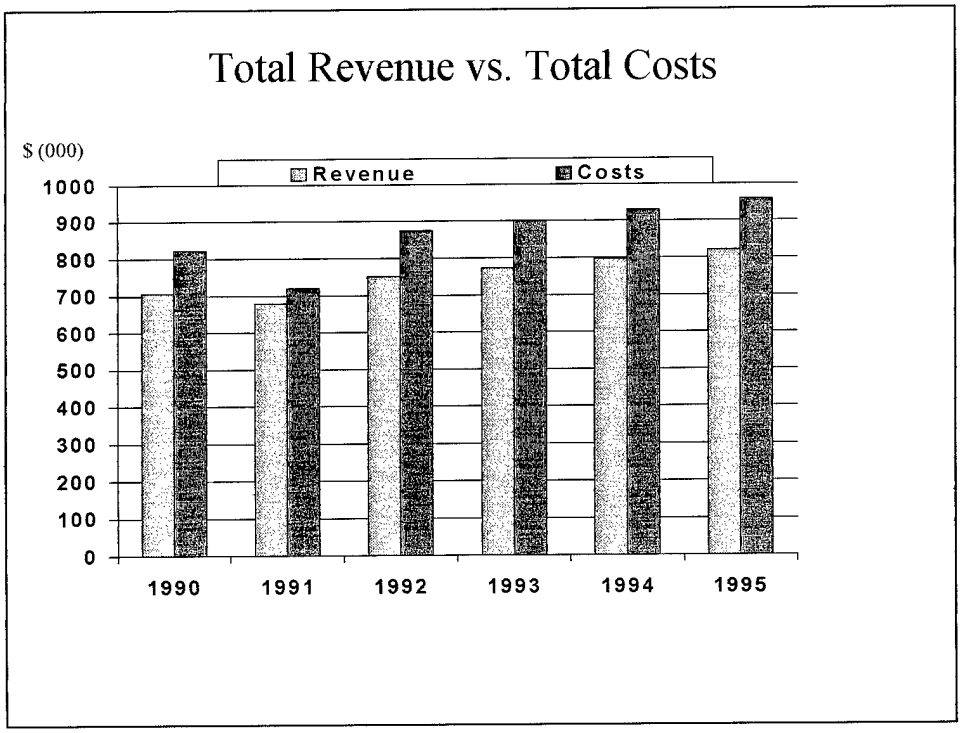


Figure 1. Graphical Presentation of Data

As the capability to put background behind graphic information displays has increased over the last several years, many more presentations are made utilizing background graphics. An example of background graphics use is provided in Figure 2. In recent years the access to background graphics capability has become widespread. As an increasing number of people become proficient in the use of these graphics options, some research should be conducted concerning the influence on decision-making of these graphics applications.

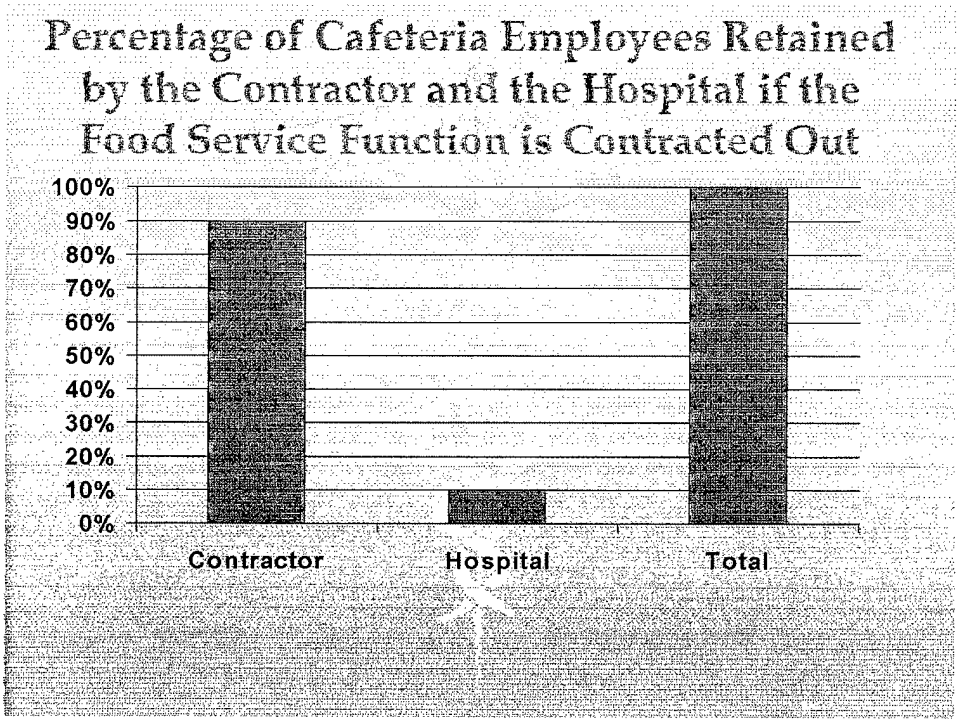


Figure 2. Background Graphics Application

The use of background fill has been referred to as "chartjunk" (Tufte, 1983: 107). Tufte defines chartjunk as "The interior decoration of graphics" (107). Using Tufte's definition, one can view background graphics as a form of chartjunk the purpose of which

is to make the graph look more professional and enhance the presentation, not the information. "Data graphics should draw the viewer's attention to the sense and substance of the data, not to something else." Tufte maintains that "a large share of ink on a graphic should present data-information" (91). He proposes that the ink used on graphs should be employed in conveying the information. The ink that fails to present additional data should not be added to graphics. Therefore, he would not advocate the use of background graphics. However, Tufte's positions are presented without empirical support. The proliferating use of background graphics, repudiated by some and endorsed by others, suggest a need for further research in this area.

Within the Department of Defense (DoD), as is happening throughout the business community, great use is being made of background graphics. Pictures of aircraft, eagles, and a plethora of other images and colors are being placed behind graphically displayed information for presentation to decision-makers. The motivation for this increased utilization seems to be an increased perception of professionalism and subliminal appeals to the decision-maker's interest.

The following two anecdotes exemplify the concern about the use of background graphics in business presentations. The first was an observation made during a fellow Lieutenant's unfortunate education in background graphics application. The second was brought up in conversation involving this thesis.

Anecdote 1.

> Colonel M flies a specific aircraft. Major W works for Colonel M and often presents him with information for decision-making purposes.

One afternoon Lieutenant A mentions that these graphics would look better, and Colonel M might favor them more, if the type of aircraft he flew was placed in the background. Upon hearing this Major W instructed Lieutenant A to find a picture of the aircraft Colonel M piloted, and have it on all subsequent graphic slides for Colonel M's viewing.

Lieutenant A was on a treasure hunt. At the time, the base had only one scanner and finding a picture suitable for scanning proved difficult. Using his resourcefulness Lieutenant A spent approximately twelve hours locating a suitable picture and coordinating the use of the base's sole scanner. These twelve hours were spent to obtain for Colonel M something he did not request and possessed questionable benefit. Did the inclusion of an aircraft as background enhance the presentation? The possibility exists that the aircraft's inclusion detracted Colonel M's attention away form the information being presented and thus hindered his ability to reach the appropriate decision.

He felt that the use of background graphics was an unnecessary enhancement that added no value to the presentation. He spent extra time on the graphs, inserting material that had no bearing on the information needed by the decision-maker.

Another case involves a school dean who was being briefed by a faculty member using slides with background graphics. The particular background graphic that was used is presented in Figure 3.

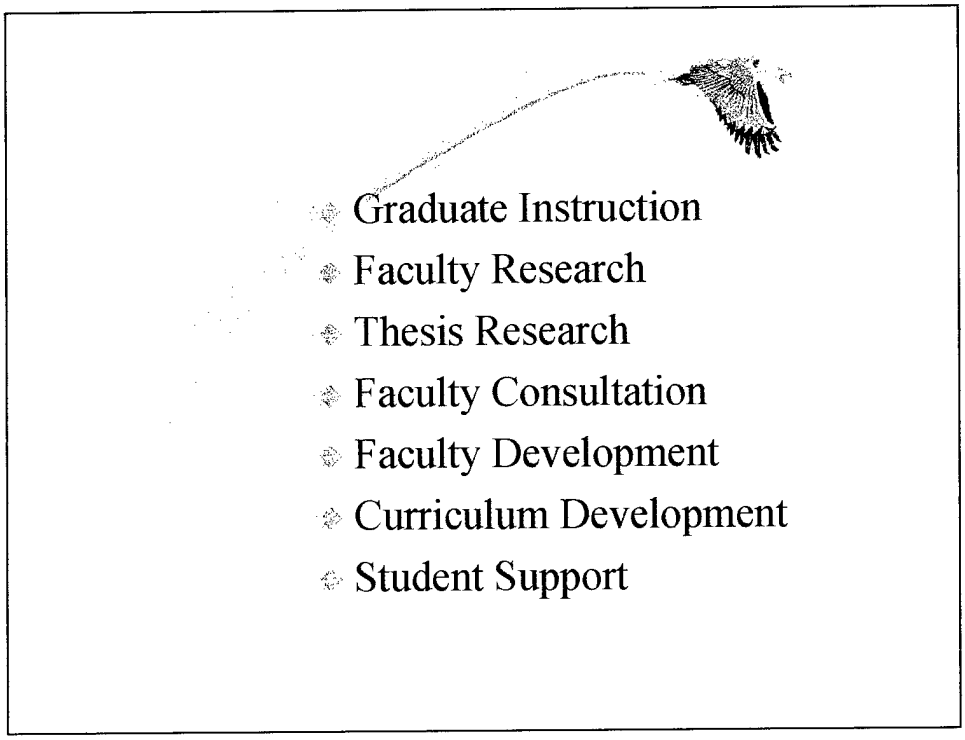


Figure 3. Example of a Criticized Graphic.

Anecdote 2.

The dean's comment was to the effect that it appeared to him that the eagle was defecating on all the important points of the briefing. His comment makes clear that his attention was being drawn away from the information being presented. Was the substance of the briefing compromised? Given such a distraction, one may be concerned that the

decision-maker's ability to objectively evaluate the information was influenced by this graphic.

Although the DoD isn't a commercial business with executives in the traditional sense, many important decisions are made daily that impact the national defense. In commercial businesses, policy makers are briefed directly by the field experts. *The sales director makes presentations to the CEO.* Given the hierarchical nature of DoD decision-making, the decisions made by lower level managers impact those at higher levels; presentations are made to each successive layer of the hierarchy. Often the briefed become the briefers at that next level. Therefore, the information presented to DoD decision-makers at all levels should be free of influential factors that are not directly pertinent to the decision at hand. If background graphics affect decision performance, the information that is to be forwarded may become adulterated by influential pictures and/or colors, *i.e. background graphics.*

The results obtained from graphics research can improve the quality of decisions reached throughout the DoD decision-making structures. Research into the use of background graphics can inform DoD personnel as to the effects of such usage on decision-makers, allowing them to better present information in ways less likely to skew the proper decisions indicated by the data. Concurrently, educated decision-makers can understand the effect background graphics have on their decision-making ability, allowing them to make cognizant adjustments in presentation requirements.

In the past, research has focused on the effects of graphical formats on decision-making. Although claims have been made about the effectiveness of background graphics,

little research has been conducted to determine the effect of background graphics on decision-making. Typical of these claims is Tufte's statement that "Chartjunk does not achieve the goals of its propagators. The overwhelming fact of data graphics is that they stand or fall on their content, gracefully displayed" (Tufte, 1983: 121). Again, background graphics are defined as any pictures or color schemes that fill in the background area behind the essential information being presented to the decision-maker. Thus the objective of this thesis is to determine whether background graphics negatively affect a decision-maker's ability to reach the appropriate decision indicated by the data presented.

Hypotheses

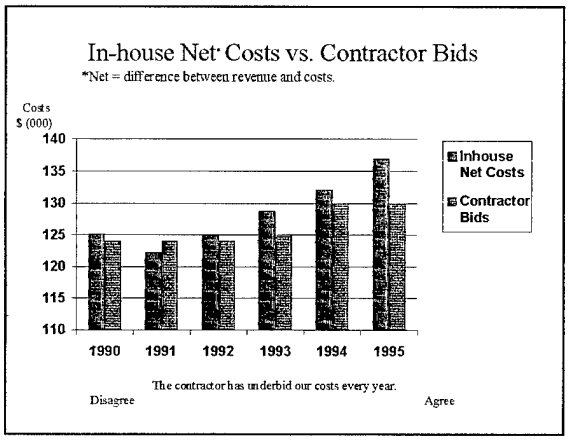
To achieve the objectives of this study two hypotheses were identified:

1. H_{01}: Background graphics do not affect decision accuracy.
2. H_{02}: Background graphics do not affect decision confidence.

The first hypothesis, H_{01}, claims that the use of background graphics does not influence a decision-maker. Figure 4 illustrates the contrast between the use of background graphics and their omission.

The null hypothesis states that no difference exists in a decision-maker's ability to reach the proper conclusions regardless of the graph presented. The graph in Panel A is identical to that in Panel B save for the utilization of background graphics and the accompanying color change automatically initiated by the graphics software.

Panel A



Panel B

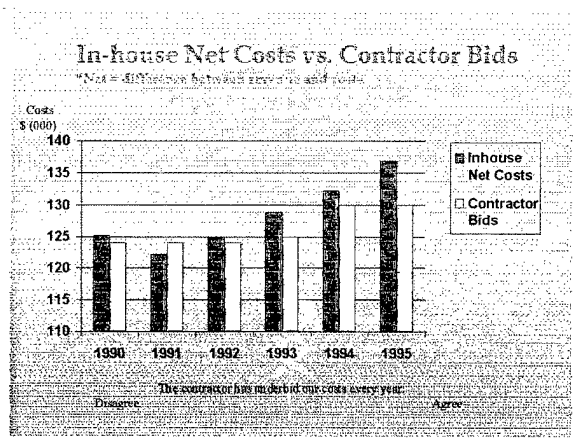


Figure 4. Comparison of Background Graphics Application

The second hypothesis, H_{02}, asserts that decision-makers are equally confident of a decision's accuracy regardless of the existence of background graphics. A decision-maker faced with a decision supported by the graph in Panel A would make the same decision if support were instead provided by the graph in Panel B.

In addition to the null hypotheses, several areas for sensitive analyses were identified. Some graphics research has found indications that gender and training have an influence on the results obtained. These two factors are addressed as investigative questions for sensitivity analysis and referred to as hypotheses three and four.

3. H_{03}: Gender does not affect H_{01} or H_{02}.

4. H_{04}: Graphics training does not affect H_{01} or H_{02}.

Analysis will be done to determine if the decision results differ based on the gender of the decision-makers. Previous research indicates that gender may play a role in how well graphical presentation of information is interpreted (MacKay and Villarreal, 1987: 544).

Also, analysis will be performed to determine if graphics training impacts decision-making performance. Training has been identified as a possible influential factor on the comprehension of graphical presentations (DeSanctis, 1984: 477). Based upon the indications of previous studies, an attempt will be made herein to establish the affect of training on decision accuracy and confidence in conjunction with the use of background graphics. Additionally, an attempt will be made to determine if the results of these sensitivity analyses are generalizable across decision tasks. Decision task refers to the nature of the decision problem.

Synopsis

An introduction to the general problem associated with the use of background graphics was provided. The general case was narrowed to identify the specific issue involved with the application of background graphics to graphic presentations. Several examples and anecdotes were given to illustrate the concerns and display the aesthetic differences between differing presentation formats. Following the explanation and examples of background graphics, the specific hypotheses employed in this study were presented and discussed.

Chapter II, the literature review, examines the research done to date on the use of graphics in conjunction with decision-making. Several studies are discussed in detail as they most closely relate to the current research topic. Chapter III, discussion of the methodology employed, explains the experimental design, its validity, applicable concepts and constructs, as well as the construction of the experimental item. Also included is an explanation an example of each graph utilized in the experiment. Additionally, the

administrative procedures utilized in conducting the experiment, the equipment used, and an explanation of the method of analysis are provided. Chapter IV, the findings and analysis, communicates the results of the experiment, utilizing the method explained in Chapter III. An excursion into the effects of graph complexity is also presented followed by a concise summary of the results. Chapter V, the conclusion, discusses the experimental results as they relate to the thesis' hypotheses. The results are then discussed in the context of their impact on the DoD. Finally, some suggestions are made concerning possible topics for future background graphics research.

II. Literature Review

A substantial number of research efforts have been conducted concerning the use of graphs as replacements for tables and narrative text. Far fewer studies have concerned the use of graphs as decision-making tools. Eleven previous studies were identified as dealing primarily with decision-making. The variables used in and the results of these eleven are summarized. In relation to background graphics, little research has been accomplished. The studies considered to have primary and ancillary information pertinent to the application of background graphics were given a more thorough discussion.

The generalizability of decision-making studies is also explored. The ability to generalize results across decision problems is crucial to the establishment of definitive conclusions. The claims made by vendors of popular software packages are presented. These vendors promote the use of software that provides numerous background graphic options.

Graphics Software

Computer graphics software packages have become a powerful means of communicating in the modern business environment. Information is presented in graphical form with elaborate background images intended to appeal to decision-makers. Software companies are less than subtle in their implication that elaborate presentations will positively influence the particular decision at hand (Microsoft, 1994: 1; Claris, 1993: W-

1). Claris claims that graphics produce attractive and professional-looking presentations. The subtle indication is that without graphics a presentation is somehow unattractive and less professional.

Another claim is that "you can create an even stronger visual framework by employing the two primary *visual elements -- graphics and type*. By balancing text with graphics, you give the reader an obvious and compelling starting point" (Apple, 1991: 26). Microsoft, Claris, and Apple create software for IBM compatibles and Macintosh systems. In addition to the claims, the background graphics available in Microsoft's PowerPoint software provides three color variations on fifty-five designs. The overtones of these software producers' claims, coupled with the numerous formats, are that graphics enhance the presentation of information, thus improving the ability of decision-makers to perform their jobs.

The boldest claim was made by Decisioneering, Inc., in the promotion of its Crystal Ball® software. "Crystal Ball is a user-friendly, graphically oriented forecasting and risk analysis program that takes the uncertainty out of decision-making." Furthermore, "With Crystal Ball, you will become a more confident, efficient, and accurate decision-maker" (Decisioneering, 1993: 1). With the large growth in the computer graphics industry, estimated to be exceeding a compounded rate of 60% per year (DeSanctis, 1984: 463; Brown, 1984: 89; Ward, 1992: 318), the effect of graphics on decision-making should be investigated. The extent to which the new generation of graphics software provides added value is a valid research question in light of the claims made and money expended for this capability.

Previous Research

Many researchers have investigated and experimented with the effect of graphics on the decision-making process. A summary of several pertinent studies is provided in Table 2. The studies in Table 2 were included because of they are relevant to the advancement of "graphics use" research. The left column lists the names of researchers responsible for the respective studies. The second and third columns reflect the independent and dependent variables utilized in each study. Finally, the right column summarizes the results of the research. If more than one dependent variable was investigated, each was numbered. The results of the research was also numbered to correspond with the associated variables.

Although numerous studies have been conducted concerning the use of bar graphs versus tables for data comparison, interpretation, extraction speed, accuracy, performance, and preference, significantly less has been done in the area of graphic's possible influence on decision-making as a whole. While extraction speed, accuracy, and performance are measures of decision-making, they do not individually possess the all-inclusive essence of decision-making. The studies included in Table 2 are representative of, but not inclusive of, the research done to date on graphics as they affect decision-making; each of these research studies utilized one or more of the measures of decision-making. However, none attempted to integrate the varying measures and tasks involved in decision-making into a decision problem. This thesis requires the use of presented data to achieve more than data extraction. The decision-maker must go beyond specific answers to questions about each graph, *i.e. extract data*. He must provide a decision based on the information contained in

Table 2. Summary of Graphics Research

Authors	Independent Variable	Dependent Variable	Results
Tullis, 1981	Narrative vs. tables vs. graphs	1. attitude 2. speed 3. accuracy 4. preference	1. graphics better 2. graphics better 3. No effect 4. graphics better
Zmud, *et al.*, 1983	Tables vs. Graphs; Task complexity	Decision quality	Graphs better for low complexity tasks; tables best for high complexity.
Corbone & Gorr, 1985	Graphs vs. Enhanced Graphs	Decision accuracy	No effect
Blocher, *et al.*, 1986	Tables vs. Graphs; Task complexity	Decision quality	Graphs better for low complexity tasks; tables best for high complexity.
Dickson, *et al.*, 1986	Tables vs. Graphs; Bar Graphs/Line	1. Interpretation accuracy 2. Decision quality	1. No effect/No effect 2. No effect/Line graphs better
Jarvenpaa & Dickson, 1986	Tables vs. Graphs	1. retrieval of information 2. Recall of information 3. Message comprehension 4. Recognizing trends 5. Recall large amounts of data	1. No effect 2. No effect 3. No effect 4. Graphs better 5. Graphs better
Davis, 1989	Tables vs. Graphs	Performance	Graphs better only when visual cues aid in answering questions
DeSanctis & Jarvepaa, 1989	Tables vs. Graphs	1. Accurate interpretation 2. Incorporate into accurate judgments 3. Confidence	1. Table better 2. Graph better 3. No effect
Larkin, 1990	High integrity vs. Misleading Graphs	Decision quality	Integrity better
Barber and Dunn, 1992	Iconic vs. Traditional Graphs	1. Accurate interpretation 2. Impression	1. No difference 2. Traditional better
Latin and Villanueva, 1994	3D Graphs vs. 2D Graphs vs. Tables	Decision accuracy	No effect

all the graphs. The subject becomes a decision maker determining a course of action rather than being limited to choices among several aspects of one data source. True decision-making involves more than one piece of information from which to extract data. In this respect, the current study's scope differs from the focus of previous research.

These works go a long way in establishing the influence of graphics in answering specific questions concerning a particular graph. They do not attempt to use a sequence of graphics to inform a decision-maker, who must subsequently utilize the information to make a decision based on more than one isolated graphic. Additionally, none of the preceding studies addresses the question of influence of background graphics on decision-makers.

Latin and Villanueva. In their 1994 AFIT thesis, Latin and Villanueva provided a comprehensive summary of tables vs. graphs research (Latin, 1994: 12-14). Their summary encompasses of all types of graph research. The focus of this work is more narrowly defined around the possible influence of background graphics on decision-making. Table 2 provides a good synopsis of the research done on graphs and their effects on decision-making. However, no previous research on the effect of background graphics on decision-making was discovered. The thrust of this literature review will now turn to the decision-making aspect of graphics research due to the absence of specific research dealing with background graphics. Because decision-making is a major component of this study, some space will be dedicated to reviewing the impact of graphics use in conjunction with decision measures, *e.g. extraction speed, accuracy, and performance.*

Davis. Davis proposed that "the most efficient form of presentation is dependent on the level of question complexity" and "the most effective form of presentation is dependent on the level of question complexity" (Davis, 1989: 498). Complexity is defined by Davis as the amount of information that must be processed by the decision-maker before an answer can be reached. "The more information which must be examined to arrive at an answer, the more complex is the question" (497). He hypothesized that the more complex a graph, the less efficient will be the decision-maker. Likewise, the more complex a graph, the less accurate will be decisions reached utilizing the graphic. As defined by Davis, complexity is the amount of information that must be examined to reach a conclusion. Therefore, a graph that includes background graphics (that is, more information), might further denigrated the decision-making task.

In this study, the presentation modes (tables vs. graphs) had inconclusive results on the questions of efficiency and effectiveness. However, Davis found an interesting interaction effect among the data. Further analysis seemed to show that "different forms of presentations are best for different tasks" (497). Davis indicates that no absolute decision concerning the use of graphs over tables can be acknowledged. That is, no one particular form of problem presentation, tabular or graphic, is best for all decision situations. On the contrary, presentation forms must take into consideration the decision task. As a concluding note, Davis points out that his findings could help to explain the inconclusive results of prior research efforts. Davis' research effort is largely inconclusive as well, but does seem to indicate that decision accuracy is enhanced when specific,

decision-related cues are used in conjunction with a decision task. A complete critique of Davis' study is contained in Appendix A

Do background graphics provide decision cues? Or, do background graphics complicate the question to be answered (the task)? The use of color schemes and pictures is the essence of background graphics. Do they influence the decision-making process? Davis' research would seem to indicate that background graphics may indeed have an influence.

The work of Tufte and Davis indicates that background graphics increase the level of complexity. The increased use of ink, necessary to fill-in backgrounds, qualifies as chartjunk (Tufte, 1983: 107). Background graphics also contribute to the quantity of information that must be processed by a decision-maker. This increase in a graph's level of complexity reduces the probability that a decision-maker can reach an accurate conclusion.

Davis' result that no one mode of presentation is better in all decision tasks creates the problem of determining what means are appropriate for deciding upon a background graphic format in a given decision situation. If each situation is best supported by differing presentation formats with problem specific cues, how can a presenter know which is most conducive to accurate decision-making? Additionally, the varying presentation modes require that the decision-maker be proficient in the interpretation of each.

DeSanctis and Jarvenyaa. In their study, DeSanctis and Jarvenyaa created a conceptual framework to incorporate extraction accuracy and judgments. Judgments, as constructed for the purpose of their study, are not decisions, but rather perceptual

recognitions of direction and position (Cleveland, 1985: 230). Cleveland claims that accurate judgments about data "can be made effortlessly and almost instantaneously" (231). DeSanctis and Jarvenpaa set out to test Cleveland's claim. Specifically they tested whether "forecast accuracy will be better when data is displayed in a graphical format than when data is displayed in a numeric format" (DeSanctis and Jarvenpaa, 1989: 511). The results of the study indicate that forecast accuracy was better using graphics while numeric tables provided more accurate interpretation -- identifying and communicating specific data values.

Corbone and Gorr. A natural tendency, given the positive effect of graphics on judgment type tasks, might be to improve or enhance the graphics containing the data.

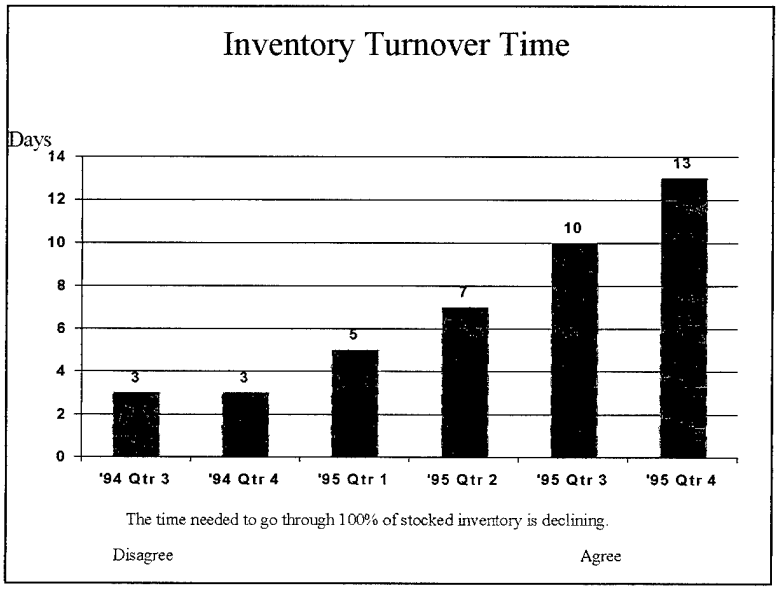


Figure 5. Enhanced Graphic

Improved or enhanced graphs refer to those that provide decision cues or redundant data to aid the decision-maker in arriving at an appropriate conclusion. However, a study that

employed this philosophy concluded that enhanced or improved graphics did nothing vis-à-vis conventional graphs to improve the decision-maker's judgments (Corbone and Gorr, 1985: 159). Corbone and Gorr's enhancements were the mere attaching of numerical references to the graph values directly on the graphic. An example of Corbone and Gorr's application of an enhancement can be seen in Figure 5. These results suggest that graph presentation is marginally beneficial to a point beyond which additional graph enhancements add no value to the task. However, the enhancements indicated in Corbone and Gorr's work do not include background graphics.

Dickson, DeSanctis, and McBride. More closely related to this thesis topic, Dickson, DeSanctis, and McBride conducted an experiment focusing on "the impact of ...technology on the quality of organizational decision-making." They point out that "overall, research on the effectiveness of graphs as decision support tools is rather sparse" (Dickson *et al.*, 1986: 40). This study compared the effects of graphics and tables on decision-making. The results of the experimentation led to the conclusion that "generalized claims of superiority of graphic presentation are unsupported, at least for decision-related activities" (40). The authors further speculate that "the experiments suggest that the effectiveness of the data display format is largely a function of the characteristics of the task at hand, and that impressions gleaned from 'one shot' studies of the effectiveness of the use of graphs may be nothing more than situationally dependent artifacts" (40). As was the case with DeSanctis, Jarvenpaa, and Corbone and Gorr, the study conducted by Dickson, DeSanctis, and McBride fails to address the effect of background graphics on decision-making. The focus of these research efforts has been to

examine the effects of using graphics to represent data rather than add aesthetics to influence decision efforts.

The idea that the effectiveness of graphics is situationally dependent is difficult to support. Dickson, DeSanctis, and McBride attempted to identify decision situations or environments in which either tabular or graphical presentation modes are superior to the other. They concluded that "claims of total superiority of graphs should be viewed with skepticism" (Dickson, *et al.*, 1986: 46). These researchers suggest that the effectiveness of graphics as a persuasion tool is superior to that of decision support. This claim is made without the necessary supporting data and for the purposes of suggesting a future research topic. Furthermore, this claim is even more pertinent to graphs with background than those without. The claims of background graphics software producers are that their background graphics features make graphs more appealing and professional. The implication being that more professionalism, in the form of graphics, will influence the decision-maker.

Graphics Research and Background Graphics

Research reported by Davis, DeSanctis, and Dickson addresses the use of graphics in decision-making tasks. However, they provide little indication, if any, as to the effect of using background graphics when presenting a decision problem to a decision-maker. A primary difference between the current study and the others summarized above is that the latter merely address performance in data extraction task activities. In these research efforts, decision tasks should not be confused with decision problems. "Tasks," as used in

graphics research, refers to a decision between two or more aspects of a graph's data (Cleveland, 1985: 231). A decision problem uses the information presented in one or more graphs to facilitate a decision between alternative courses of action. In this respect, the purpose of this thesis is decidedly different from previous graphics research and experimentation efforts.

A secondary difference between this study and others previously conducted is the essential nature of a "graphic." As used in previous research, a graphic representation refers to data presented in the form of bar charts, pie charts, or other creative non-narrative forms. The focus of the current work is on background graphics, defined as the use of images, pictures, and color schemes to fill in the background area behind the graphics of a presentation. The widespread use of such background graphics is relatively new to the field, becoming available only recently in conjunction with the proliferation of inexpensive, user-friendly software packages.

On a tertiary level, the generalizability of the previous research has consistently been cited as a definite limitation (Davis, 1989: 505; DeSanctis, 1989: 523; Dickson, 1986: 46). This limitation is due to the task nature of the experimentation. Previous experiments and studies have used several graphic and table data sets to extract answers to specific questions concerning particular subject matter. This work differs from previous studies in its attempt to generalize across decision problems in determining if background graphics affect decision-making.

Summary

While research exists recommending both the use and non-use of graphics in decision-making processes, little, if anything, has been done in the area of background graphics. The predominate research relating to graphics as an influence on decision-making was summarized in Table 2. The studies that dealt specifically with graphics and decision-making were discussed in some detail. The results of these studies were evaluated in terms of their connection to background graphics.

The bulk of graphics research has dealt extensively with the use of graphs for displaying information. Taken as a whole, the results of previous research efforts have been inconclusive. However, little attention has been given to decision-making tasks as a whole versus component measures of reaching a decision. Additionally, the use of graphics has been limited to the graphical display of information. This thesis expands graphics usage to include all types of graphical pictures, icons, and color schemes available for incorporation into presentations to decision-makers. This work is specifically interested in determining if decision-making (as a whole, not its individual measures) is influenced through the use of background graphics.

III. Methodology

The purpose of this research effort is to determine whether background graphics affect decision-making. The experimental design is described. Additionally, a discussion is provided concerning the experiment's construction and the characteristics of the population and sample. Following this discussion, a description is provided of the support equipment necessary to administer the experiment and analyze the data obtained. The latter part of this chapter discusses the analysis to be performed on the data to test the proposed hypotheses.

The hypotheses proposed for this effort are these:

H_{01}: Background graphics do not affect decision accuracy.

H_{02}: Background graphics do not affect decision confidence.

The purpose of hypothesis H_{01} is to test whether the use of background in conjunction with graphic data presentation impacts the accuracy of the decision-maker. For the purposes of this study, accuracy is determined to be the ability of the decision-maker to reach the conclusion indicated by the data presented in the graph. The decision-makers are experimental subjects who are asked to draw conclusions based upon the data presented in graphical format.

The second hypotheses, H_{02}, is to determine if the use of background graphics influences the decision-maker's level of confidence in the decision. A decision-maker's confidence level is self-defined; the subject is asked to reveal his or her confidence in the

conclusion reached. Confidence refers to the decision-maker's level of assurance in the derived conclusion.

Experimental Design

The design of the experiment is 2 x 2 factorial. Factor 1 was the application of background graphics. Background graphics was defined as the use of pictures and color schemes in the background of graphically presented data. The two levels within factor 1 are the presence of background graphics and no background.

Factor 2 was decision problem. Two separate decision problems make up this factor. The first problem involved an outsourcing decision, the second a benchmarking decision. Other researchers have referred to differing problems as different decision tasks or environments (Davis, 1989 and Dickson, 1986). Outsourcing refers to the decision involved in determining if a firm should continue to produce a good or service internally or purchase the product from an external source. Benchmarking is the process of comparing a firm's performance, in a given area, against the best practices among all firms that perform the same or analogous functions. Typically, benchmarking is done to determine whether assistance will be sought to improve performance in the area being compared.

The control groups, one for each decision problem, were presented the graphs without background graphics, while the experimental groups were shown graphs containing background. Each control and experimental group was exposed to only one decision problem.

The design of this experiment is illustrated in Figure 6. Factor 1 is identified as "Background." The lack of background graphics is denoted by a "0," meaning that no background was presented. The "1" indicates that background graphics were placed on the graphs. Factor two is classified as "Decision Problem, with "0" denoting the outsourcing decision problem and "1" the benchmarking.

Table 3. Experiment Design

			Decision Problem 1 Outsourcing	Decision Problem 2 Benchmarking
Background	0	No		
	1	Yes		

The equation of this experimental design takes the following form:

$$\text{Response} = \mu + DP + BG + (DP*BG) + e$$

where, DP = decision problem
BG = background graphics
(DP*BG) = the interaction of DP and BG, and
e = the error term.

The response variables used to test H_{01} and H_{02} are decision accuracy and confidence. Both decision problems were constructed to elicit a positive response. The decision response was obtained from the subjects immediately following their viewing of the graphs. A correct response was coded "0" and an incorrect one "1"; see Appendix G for illustration. The subjects indicated either "No" or "Yes" on the answer sheet provided (Appendices D and E).

The subject's confidence in their decisions was ascertained using the demographics questionnaire. Question 10 asked:

> Based solely on the information provided, how confident are you that you made the appropriate overall, final decision?
>
> 1 2 3 4 5 6 7
> not confident confident

The responses of each of the subjects were recorded and used in the analysis as their confidence level. Again, Appendices D and E contain the responses for each respondent.

Experimental Subjects

The population of this experiment is the public in general because virtually everyone in society is exposed to graphics. Everyone makes decisions based upon data presented in graphics form with background images behind the information. These decisions range from purchasing goods using graphically-presented marketing techniques to learning from academic materials using graphs to conserve type-space. This conservation is evident when data from many pages is presented in a single graphic. Mainstream newspapers and magazines are full of examples where people are presented with options augmented by background graphics. Companies often embed their logo in the background of their financial reports as well as their advertising campaigns.

Air Force Institute of Technology (AFIT) Professional Continuing Education (PCE) students represented the general public. The PCE classes selected for this study were dependent upon course director and instructor approval. This approval was

dependent upon class availability and schedule. No specific classes were targeted for use in the sample. While a convenience sample is considered by some to be the least reliable in support of design (Emory, 1991: 274), it has been used in previous experiments (Larkin, 1990; Barber and Dunn, 1992; Latin and Villenueva, 1994). Additionally, the use of students for exploratory "theory building" research seems appropriate.

> [F]or activities of the type our experiments require, there is no reason to believe that students would perform any differently than managers. Additionally, for this kind of work, one needs the power in tests that can be obtained by the large numbers available in student subjects. (Dickson *et al.*, 1986: 46)

Therefore, the use of PCE students should not present a weakness to the experiment's design. Moreover, the typical PCE student is a management level decision-maker who is exposed to background graphics as much as individuals in the population. By not targeting specific PCE courses, the sample will include a broader base of the population, *i.e. military officers and enlisted personnel, DoD civilians, and defense contractors.*

Experiment Construction

Initially, decision problems were sought that could be supported by relevant background graphics contained in PowerPoint® 4.0 and were simple enough to administer in less than 20 minutes. This time constraint was imposed due to the nature of the subject sample groups. The PCE classes could dedicate only a limited amount of time to the experiment. The decision problems chosen involved questions concerning outsourcing and benchmarking. These decision problems were chosen because they represent the decisions currently being considered in today's market. Another reason for their choice

was the existing, accepted measures of evaluating the criteria involved in reaching a decision on these problems.

Each decision problem was supported with six graphs that led to an appropriate decision. The appropriateness of the decision was determined based on the overall indication of the data contained in each graphic. The correct decision was determined as the one that would be implied solely based on the information in the graphs. The financial and performance trends indicate a clear decision alternative. Additionally, each graph contained a statement at the bottom with which the subjects were to indicate agreement or disagreement. Figures 6 through 17 indicate the statements included on the graphs. The responses for each of the six graphs, used in each decision were consistent across both the decision problems; *i.e. the correct response to each graph was the same regardless of the decision problem.* Both decision problems consisted of three agree and three disagree graph responses. The appropriate answer to both decision problems was "yes." The service provided in the outsourcing problem should indeed be outsourced and the firm in the benchmarking problem should benchmark its process. Thus, the decision problems were parallel in construction. The correct responses for each graph were identical across both the decision problems, as well as the experimental and control groups.

Explanation of the graphs used in the experiment and the identified correct answers are provided to enhance the understanding of the decision-making process involved with each decision problem. The outsourcing decision problem casts the experiment's subject as the Chief Executive Officer (CEO) of a major metropolitan hospital, whose board of regents has charged with the task of determining whether the

hospital should continue to operate its cafeteria. Based solely on the information contained in the graphs, the subject must decide whether to maintain in-house operation of the cafeteria or contract out its function to a commercial food service contractor. A full explanation of the decision problem may be obtained from Appendix D.

The first graph presented to the outsourcing decision-makers dealt with the comparison of in-house operation costs with the bids of a contractor offering to provide the service. A comparison of the type included in Figure 6 is pertinent to any decision concerning the potential for outsourcing. The contractor has underbid the in-house costs

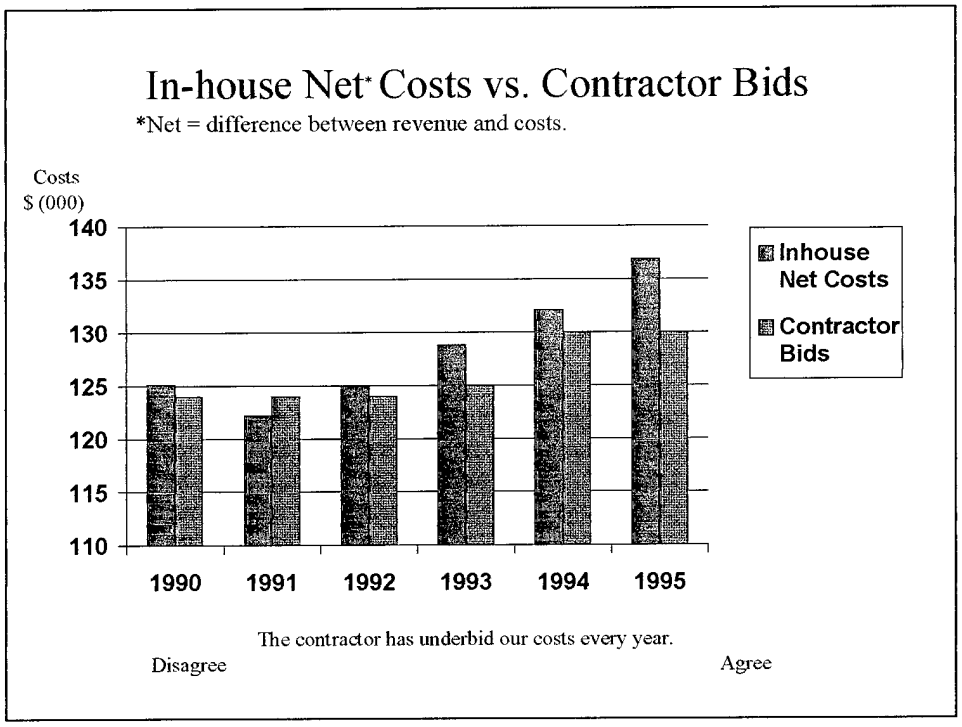


Figure 6. First Outsourcing Graph

in each year under consideration save one; therefore, the appropriate response to this graph is "disagree."

In the second outsourcing graphic, Figure 7, the revenue generated by the cafeteria is plotted against the costs associated with its operation. The correct response would be to agree with the statement associated with this information. A comparison of total

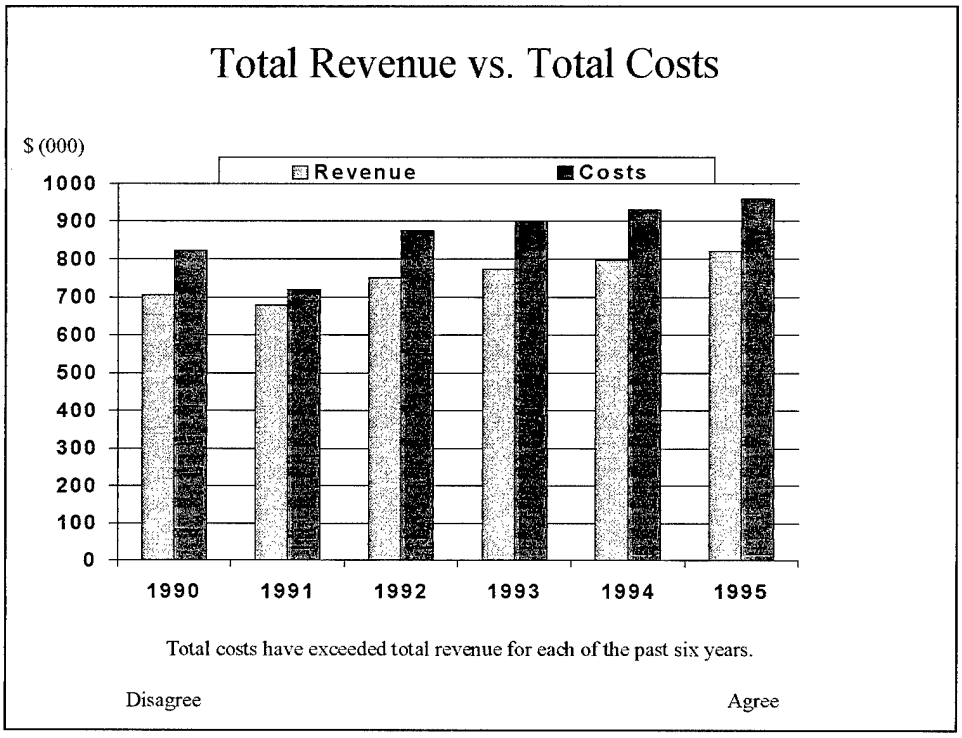


Figure 7. Second Outsourcing Graph

revenue against total costs is vital to understanding the potential for short run as well as long run profitability. This understanding serves as valuable information in the overall decision problem.

In Figure 8 the comparison between costs and revenue is made in a different way. The differences between the numerical values from Figure 7 are graphed to show the magnitude of the differences by year. The response to the statement on the Profit and

Loss graph is "agree." Each of the first three graphs speaks to the financial dimensions of reaching a decision concerning outsourcing.

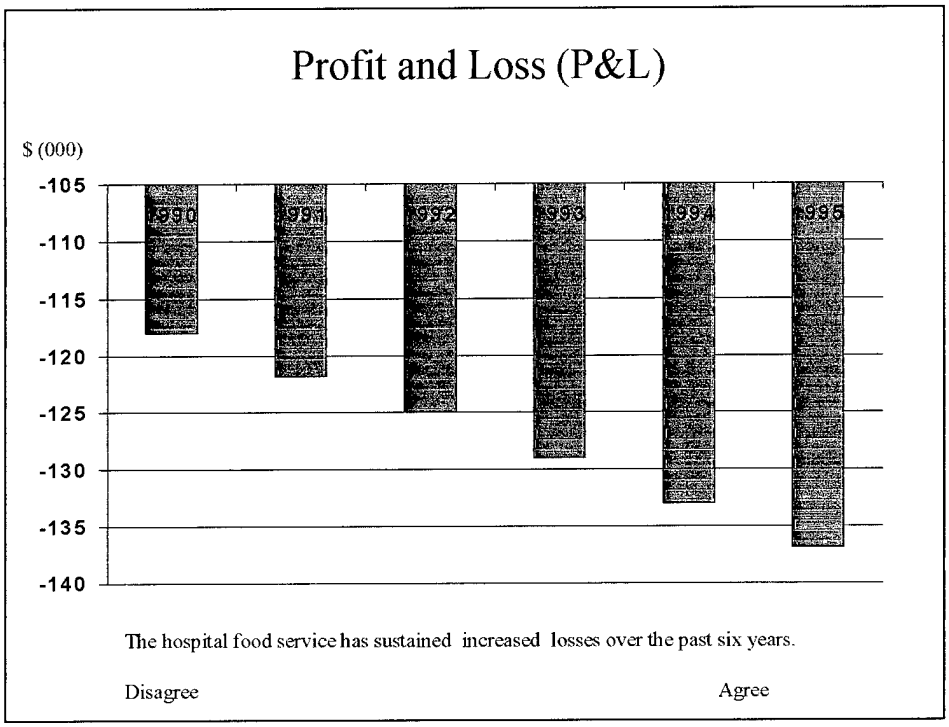


Figure 8. Third Outsourcing Graph

In addition to the financial aspects of outsourcing, other factors can be readily identified. Figures 9 and 10 address the subject of customer satisfaction. Satisfaction with the internally operated cafeteria has been on the decline, but has not decreased every year over the entire period under consideration of this decision. Therefore, the necessary response here is "disagree." Conversely, the potential contractor reports that customer satisfaction, in facilities under its management, is generally increasing. Joined with the data in Figure 9, the non-financial information also tends to indicate that the contractor offers an alternative

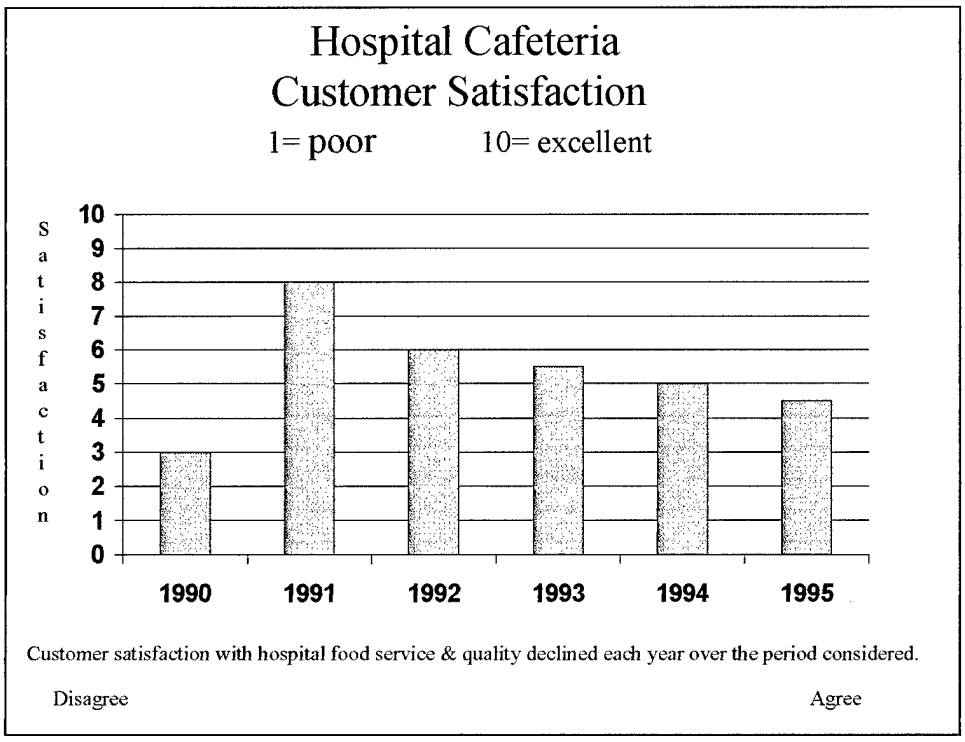


Figure 9. Fourth Outsourcing Graph

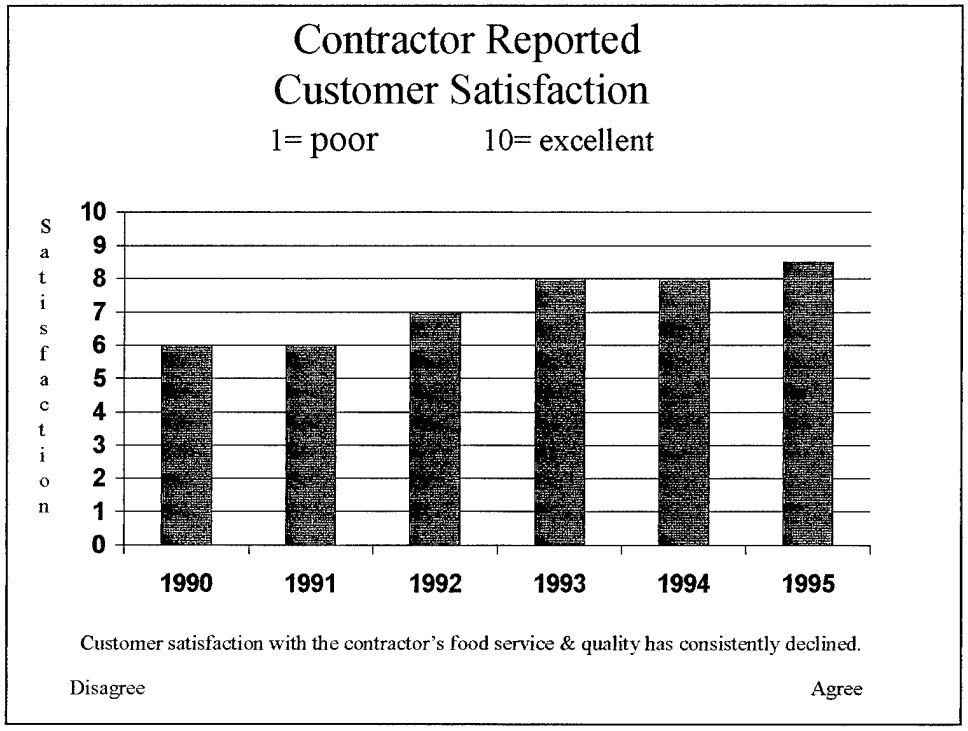


Figure 10. Fifth Outsourcing Graph

superior to continued in-house operation of the food service facility. The logical answer to Figure 10's graphic is "disagree."

Another important subjective, and perhaps politically motivated, factor in decisions to outsource are the displacement of employees. Therefore, the subject of the graph in Figure 11 is the continuation of employment. The contractor has agreed to "keep-on" 90% of the cafeteria payroll, if allowed to contract for the service in question. The other 10% are staff employees who will be retained by the hospital. Therefore, no cafeteria employee is to lose his or her position due to the outsourcing of the hospital food service. So the response to this graphic should be "agree"; furthermore, this graph supports the affirmative case for outsourcing.

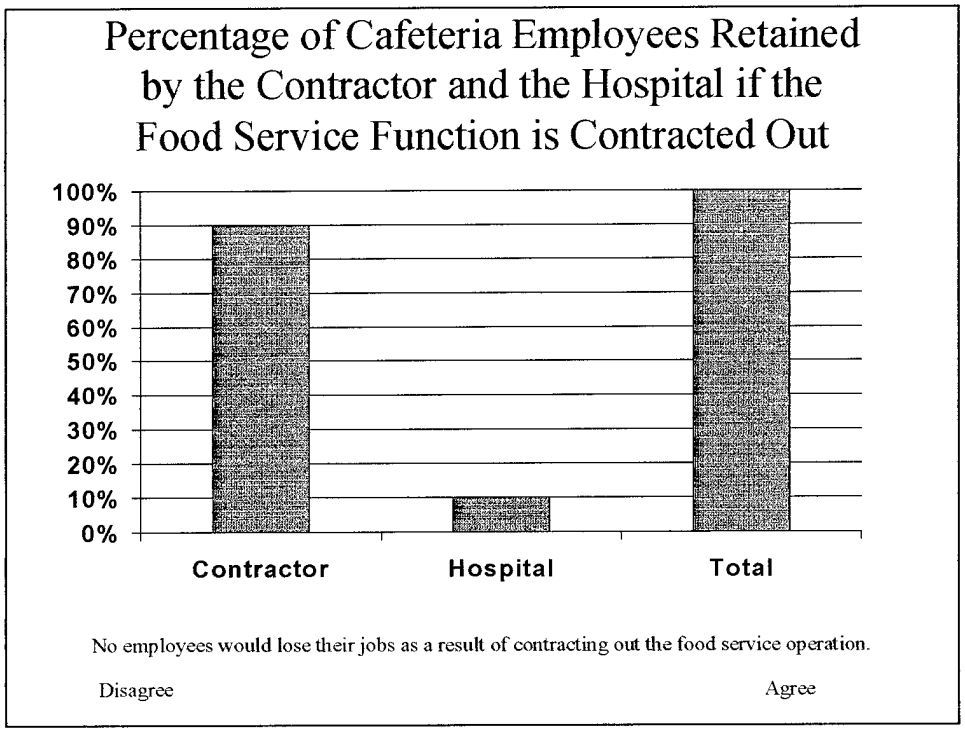


Figure 11. Sixth Outsourcing Graph

Each of the six outsourcing graphs, contained in Figures 6 through 11, provides the decision-maker with information supporting the conclusion that outsourcing is the appropriate decision.

The graphs contained in Figures 12 through 17 are those presented to the benchmarking decision-makers. Each subject in the benchmarking decision problem is cast as the Chief Executive Officer (CEO) of a large industrial firm that produces and distributes ball bearings. Over the past six quarters (1 ½ years) it has come to the management's attention that something is wrong with the firm's distribution process. No one within the company can exactly identify the problem. Based solely on the information contained in the graphs, the subject must decide whether to continue working the issue in-house or consult the world's most efficient distributor for assistance in evaluating/benchmarking your company's distribution process.

All the graphs are constructed to yield the answer that, yes, the firm should benchmark its process. Support for this conclusion begins in Figure 12 with a representation of the firm's distribution costs. These costs have been on the rise in recent quarters, while those of the firm's closest competitor have remained unchanged. Clearly, the indicated response to this graphic is "disagree." The firm's distribution costs have risen, suggesting that some action is necessary to control these costs.

In addition to the cost information presented in Figure 12, the financial strength of the firm is in decline. In Figure 13, the decision-makers are presented with the declining

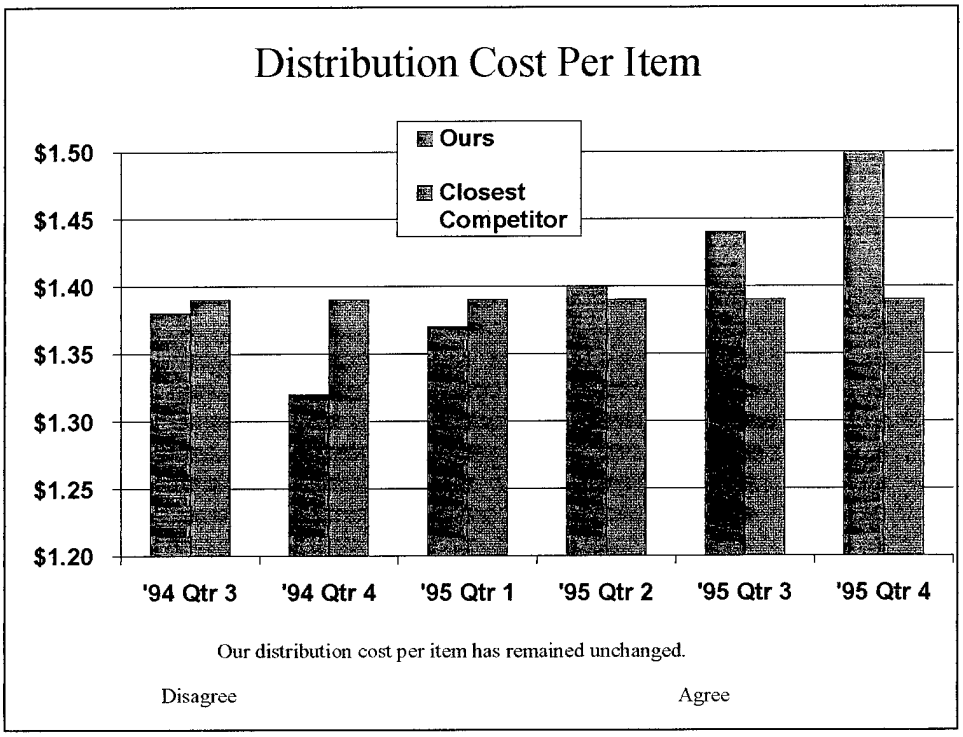


Figure 12. First Benchmarking Graph

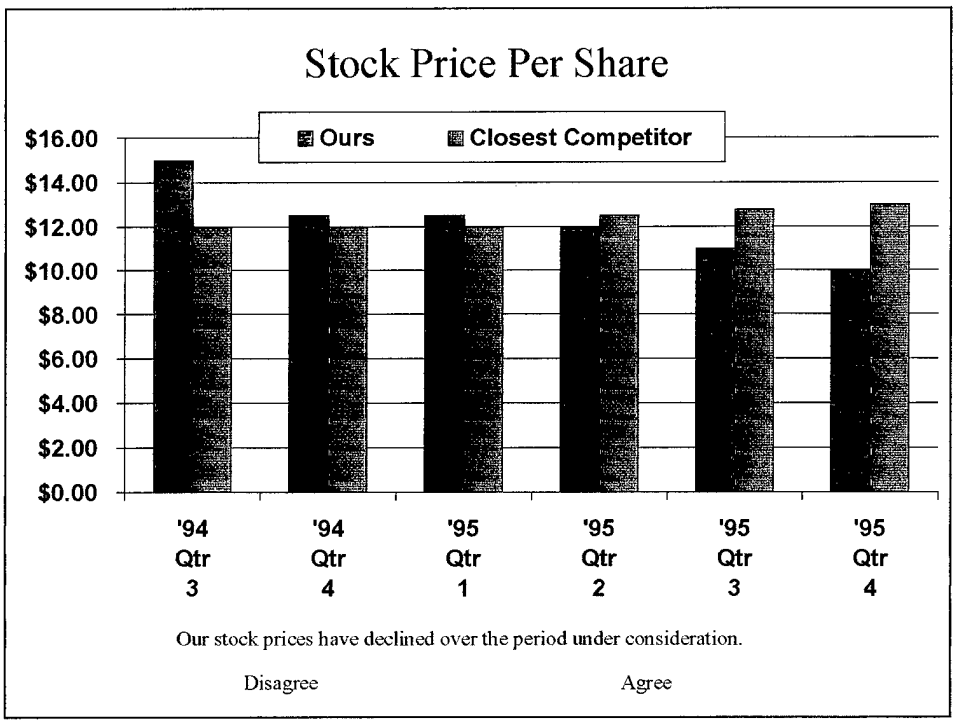


Figure 13. Second Benchmarking Graph

price of their stock vis-à-vis the firm's closest competitor. The stock prices have been in general decline over the entire period under review. The appropriate response to the statements at the bottom of each of these two graphs is "agree."

An accompanying item is displayed via the graphic in Figure 14. The firm's market share has decreased each of the last three quarters, while the competitor's has been increasing. The trends show a decided change in the firm's relationship with its competitor.

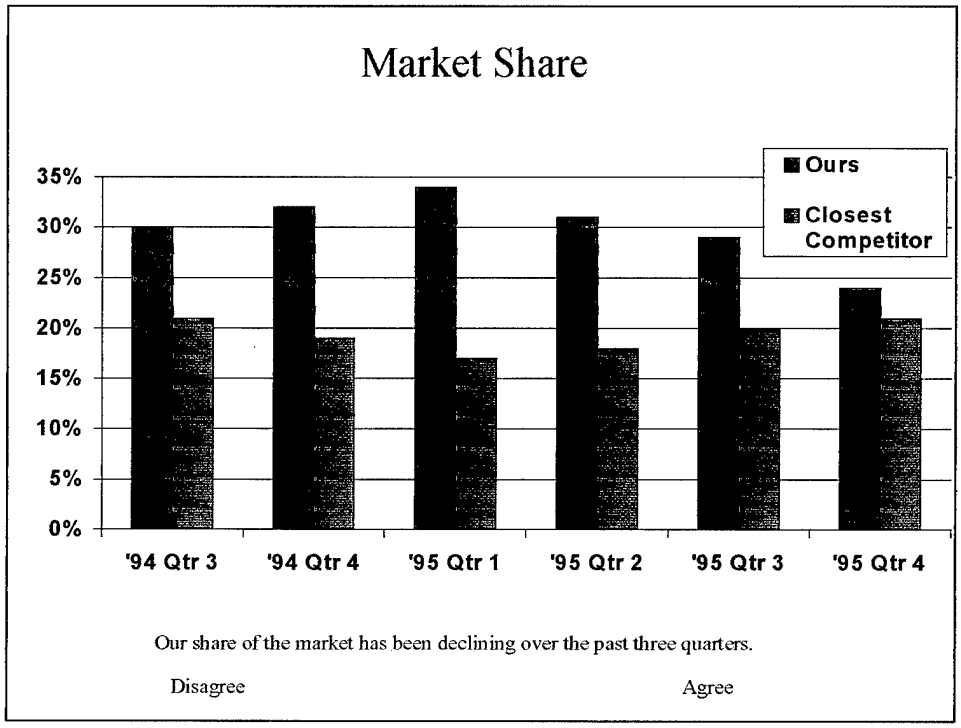


Figure 14. Third Benchmarking Graph

The decision-making process is further swayed in the direction of benchmarking by the information presented in Figure 15. This figure depicts the cycle time of orders, in

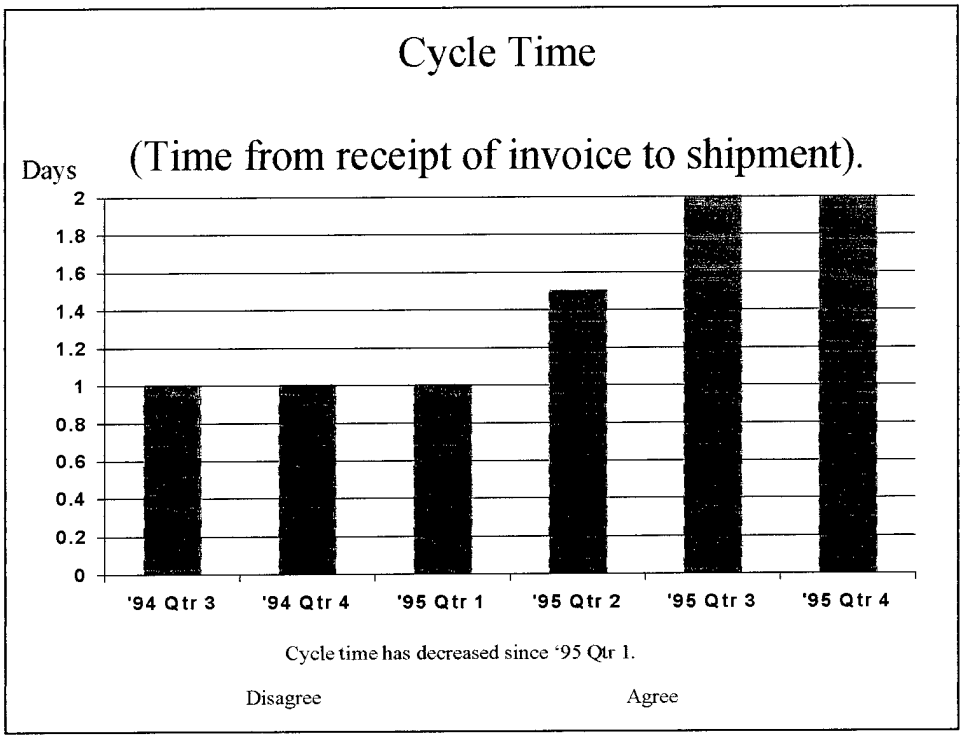


Figure 15. Fourth Benchmarking Graph

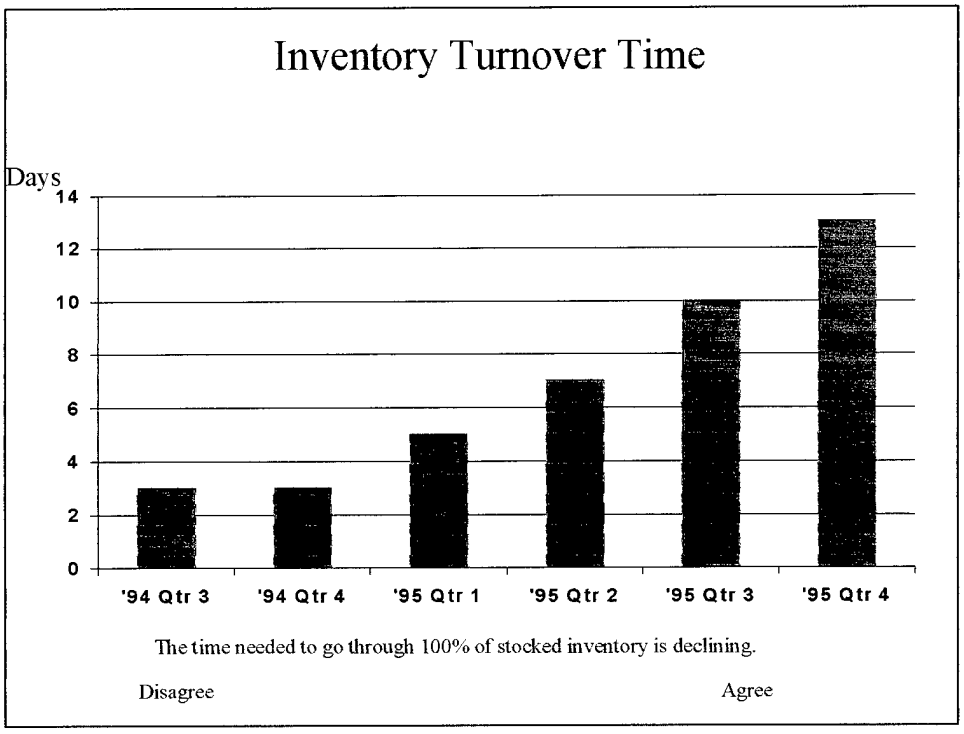


Figure 16. Fifth Benchmarking Graph

which there has been a drastic increase. The cycle time has not improved. In fact, the time required to cycle an item through the process has doubled. Therefore, the correct answer to the accompanying statement is "disagree." Orders previously processed in one day now take twice as long.

Just as the time to process orders has increased, so has the period required to turn inventory. The inventory turnover time depicted in Figure 16 is not improving, but deteriorating. The correct response to this graph is also "disagree."

The graphs explained thus far indicate, through financial and non-financial measures, that an internal problem exists. The final graph (Figure 17) conveys the message that the problem has become noticeable outside the firm. The firm's internal

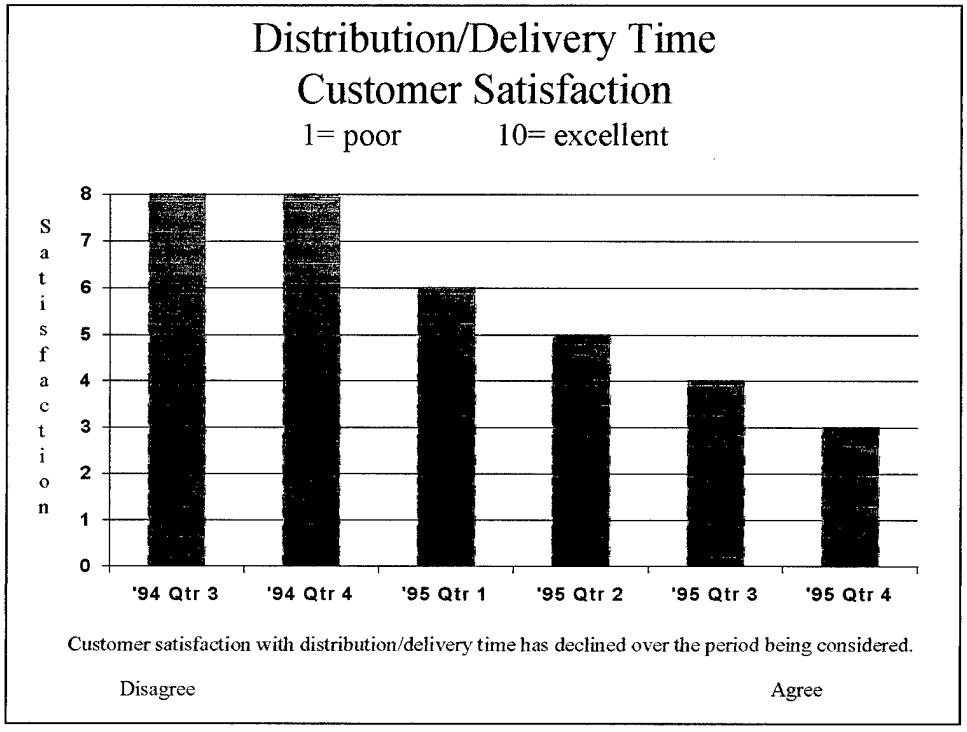


Figure 17. Sixth Benchmarking Graph

problems are impacting its customers. The decision-maker should agree that customer satisfaction has decreased over the decision period.

These trends would indicate that action needs to be taken to halt the decrease in these performance measures and find a means to correct the perceived problem. Benchmarking is indicated as most helpful because no one within the organization has been able to identify the problem. The use of an external benchmark, that is expert in the process, seems to be the proper decision.

The construction of each decision problem and its accompanying graphical information was accomplished to facilitate decision-making, thus testing Hypotheses 1, H_{01}. The slides were constructed in PowerPoint® in conformance with the criteria for high-integrity graphics (Larkin, 1990: 21-22; Christensen and Larkin, 1992: 131-145). The graphs themselves were all bar charts. The graphs were projected on a screen in front of the room using a LitePro® InFocus® projection system. Appendix B contains the graphs pertaining to the outsourcing decision problem, while Appendix C has those associated with the benchmarking one. Each of these appendices houses the graphs as seen by the studies' subjects.

Background was added to the graphs using PowerPoint® 4.0 templates; the backgrounds used for the outsourcing and benchmarking decision problems can be found at the end of the following, respective paths: msoffice\powerpnt\template\clrovrhd\ medicalc.ppt and msoffice\powerpnt\template\clrovrhd\worldc.ppt. Color was used in the experiment to facilitate increased external validity. Few presentations seen by this writer

and this thesis' advisor have been of the black and white variety. Using color in the experiment was considered crucial to external validity.

Using the slide timings option in PowerPoint® tools menu, each graphic slide was programmed to appear for 20 seconds. During this time interval, the respondents were asked to read the topic of the slide, determine the required task, view the graph, and respond using the answer sheet. The 20 second time limit was imposed to mimic the time constraints present on decision-makers in the population environment. The interval chosen was to allow adequate viewing without providing time for over-analysis. Decision-makers in the population must make many quick decisions without the benefit of reflection and excess thought. The selection of 20 seconds met with positive feedback by all the participants in the pilot study.

The Experiment

Prior to the administration of the experimental instrument, pilot tests were conducted on AFIT faculty and students. These tests were limited in that the number of subjects was kept small; twelve subjects participated in the pilot. The reason for this minimum participation pilot testing was to facilitate comprehensive feedback from the respondents. Following the experiment, each participant was independently quizzed. They were asked questions concerning: (1) the length of the decision problem explanation; (2) the time constraints placed on the viewing of each graph; (3) the clarity of the instructions; and (4) their ability to execute the tasks required.

The first concern was with the length of the decision problem introductions and explanations. Appendicies D and E contain the instruction and explanation package. These appendices also contain the answer sheet and demographics questionnaire that was completed by the subjects. The length of the instructions and explanation of the decision tasks and problems were important. The success of the study was dependent upon the attentiveness of the subjects. This required that a balance be reached between providing enough information to facilitate a representative decision and overloading the subjects with so much explanation that they became disinterested in conscientious participation.

The second question addressed the use of the time constraints. The exposure to the graphs was timed. The decision to present the information in this manner revolved around eliminating boredom and modeling the haste with which decisions are often made in the external environment. The time was important because it was key to allowing sufficient time to comprehend the information being presented, while continuing to progress the experiment at a pace that would not thwart interest.

In regard to questions three and four as posed to the pilot group, it was necessary to determine if the instructions were clear and understood by all. Likewise, the ability to execute the tasks asked of them throughout the course of the experiment was crucial to the success of the study. The purpose was to determine if the experimental instrument was constructed in such a way as to be comprehensible and executable by the intended subjects.

One major redesign of the experiment resulted from the pilot testing. Subjects tended to get over-involved in responding to the individual graphs and forgot that a

decision, based on the graphs, was required at the end. To remedy the influence of this tendency on the experimental results, a second section was added to the experiment. This supplementary section allowed the subjects to view all six graphs again for 10 seconds each. Following this second viewing, each subject was again asked to indicate his or her answer to the decision-making problem.

The experimental packages were handed out to the subjects. The subjects were instructed to keep the packages closed until told to begin. Once instructed to start, the subjects opened the packages and were given sufficient time to read the decision problem and the accompanying instructions; this usually took between three and five minutes. Once all subjects had familiarized themselves with the problem at hand and the instructions, the experiment was begun. The graphs were shown on a standard wall, projector screen using a PowerPoint® slide show running on an InFocus® LCD projector. To accompany each slide, the subject's packages contained an answer sheet that had the statement on each slide reproduced on it. The subjects viewed the projected graph and responded whether they agreed or disagreed with the statement corresponding to each of the six graphs. This process can be better understood by comparing the packages in Appendices D and E with their respective graphic slides contained in Appendices B and C, respectively.

Answer sheets were handed out with the packages so that each respondent could make uninfluenced decisions. If verbal responses were taken, the bias of one individual might influence others. The determination was made to present the slide show to a group in a room versus to each individual on a computer terminal in order to provide an

environment more like the one in which decisions of this nature are typically made. The influences of background graphics on decision-making are not as readily apparent when sitting inches away from a monitor as they are when positioned several feet from the graphic. After choosing this method of answer collection, it was decided to provide the instructions in the same format. Therefore, the packages contained in Appendices D and E were formed. Providing instructions in this manner reduced the risk that details of the instructions would be missed due to the subject's proximity to an information-intense graphic. Thus, the instructions were provided along with the answer sheet and demographics questionnaire in the packages rather than included in the slide show.

Once the subjects progressed through all six slides, they were asked to provide an answer to the decision problem. The next slide informed the subjects that they would be allowed to review the graphs to confirm their decision. This second time through the slides, the computer advanced them more quickly -- every 10 seconds. The amount of time to review each slide was reduced because the subjects would be familiar with them and no task was required -- recording answers -- the second time the graphs were viewed. To this end, the statements for agreement or disagreement were removed from the graphs for the second viewing. At the conclusion of the graph review, each respondent was asked if he or she would make the same decision now as before the review.

For the purposes of categorizing responses, a correct response in the review portion of the experiment is considered an accurate decision. This means that even if the respondent incorrectly answers the decision problem but reverses that response upon review of the graphs, the response will be considered correct of the purposes of this

experiment. The determination for such a categorization was made as a result of the feedback during the pilot testing. This adjustment allows for over-involvement in the data extraction tasks involved in the first viewing of each graph.

This adjustment provides allowances for the possibility that an initial incorrect decision may be attributable to over-involvement in the data extraction task accompanying each graph. Such over-involvement would detract from the decision-making process, but not be attributable to the experimental treatment being tested. The second pass through the graphs eliminates the extraction tasks and allows the subject to concentrate on the decision problem. The influence, if any, of the background graphics on the decision should remain throughout both viewings.

Experimental Validity

Experimental results are practically impotent if they fail to reflect the conditions of the external environment. Designs that eliminate, to the maximum extent possible, the threats to internal validity tend to lose their external validity. The attainment of one is achieved at some expense to the other. Researchers must be aware of the tradeoff between the two types of validity.

The existence of this tradeoff necessitates a discussion of the threats to internal and external validity. Internal validity questions the experiment's ability to accurately estimate the relationship of the variables being tested. The seven major threats to internal validity:

1. *History,* the specific events occurring between the first and second measurement in addition to the experimental variable.

2. *Maturation*, processes within the respondents operating as a function of the passage of time per se (not specific to the particular events), including growing older, growing hungrier, growing more tired, and the like.

3. *Testing*, the effects of taking a test upon the scores of a second testing.

4. *Instrumentation*, in which changes in the calibration of a measuring instrument of changes in the observers or scorers used may produce changes in the obtained measurements.

5. *Statistical regression*, operating where groups have been selected on the basis of their extreme scores.

6. Biases resulting in differential *selection* of respondents for the comparison groups.

7. *Experimental mortality*, or differential loss of respondents from the comparison groups (Campbell and Stanley, 1963: 5).

With respect to this thesis, history will not be a factor because the test is administered in one setting with no allowance for outside effects. The total estimated time of the experiment, based on the pilot study, does not exceed 15 minutes. Therefore, the effects of maturation are greatly reduced. No testing influences are present since the design is posttest only. No experience is gained from a pretest that might influence the experimental or control test results.

Threats four and five are non-factors because the structure and content of the measurement items were held constant throughout the test packages for both decision problems and between them. The possible effect of experimental mortality was not expected. Since subjects were only active participants in the experiment for approximately 15 minutes, the likelihood of a loss of respondents is remote.

The difficulties associated with statistical regression and selection are reduced through randomization (Campbell and Stanley, 1963: 23-24). Subjects were considered randomly assigned based on the random nature of selection to attend PCE courses. The major commands divide up the student slots in such a way to ensure/provide random selection/attendance of PCE courses. Given the difficulty in administering the experiments to ensure external validity and scheduling agreeable time periods for test administration, the randomness of the PCE selection process was assumed adequate for the experiment.

External validity reflects whether a relationship can be generalized across the population for extended periods of time. Four threats to external validity exist:

> 1. The *reactive* or *interaction effect* of *testing*, in which a pretest might increase or decrease the respondent's sensitivity or responsiveness to the experimental variable and thus make the results obtained for a pretested population unrepresentative of the effects of the experimental variable for the unpretested universe from which the experimental respondents were selected.
>
> 2. The *interaction* effects of *selection* biases and the *experimental variable*.
>
> 3. *Reactive effects of experimental arrangements*, which would preclude generalization about the effect of the experimental variable upon persons being exposed to it in nonexperimental settings.
>
> 4. *Multiple-treatment interference*, likely to occur whenever multiple treatments are applied to the same respondents, because the effects of prior treatments are not usually erasable (Campbell and Stanley, 1963: 5-6).

A primary advantage of this experiment's design is its avoidance of reactive or interactive effects of testing. Since no pretest was performed, the respondent's sensitivity

to the experimental variable was not compromised. Therefore, the results of this design should be more representative of the population than any utilizing a pretest-posttest design.

The effects of selection biases were not directly addressed because of the construction of the experiment. All members of each group were exposed to the graphs in the same order. The graphs were projected on a screen in front of each group. So, in reducing the reactive effects of experimental arrangements, little was done to control selection bases.

The reactive effects of experimental arrangements should be significantly reduced because the experiments were conducted in classroom/briefing room settings that are representative of the non-experimental environment. The treatment was facilitated by showing the graphs on the screen in front of the room. Each subject was given the statement of the decision-problem and the instructions in paper form. The graphs were shown and the subject's recorded responses on the answer sheet provided. No graphs were given to the subjects in paper form. This design resembles, as closely as possible, the nonexperimental environment in existence for the population regularly exposed to background graphics in decision-making contexts.

The threat of multiple-treatment interference is not applicable due to the posttest only design of this experiment. This threat poses no problem to the experiments external validity as the subjects were tested only once.

Other Factors

In addition to external and internal validity, several other factors should be considered in relation to the experiment. Reproducibility of the results is dependent upon the replicability of the experiment. To facilitate reproducibility all values used to produce the graphs used in decision problems one and two, *i.e. outsourcing and benchmarking, respectively*, are contained in Appendix F. Anyone proficient in the use of Microsoft® PowerPoint® version 4.0 and the data in the appendix should be able to reproduce the graphs, provided that they adhere to the criteria for high integrity graphics (Larkin, 1990: 21-22; Christensen and Larkin, 1992: 131-145). Each graph was created in Microsoft® PowerPoint® using Larkin's and Christensen's criteria. If reproduced according the aforementioned specifications, reproducibility of the experiment should not present difficulty.

Reliability of the experimental item is unknown because no other use of this instrument has been made. Therefore, the consistency of responses over time, using this instrument, is indeterminable at this time. Additionally, several other factors impact the replicability and reliability of this experimental instrument: use of the same questions, time constraints on the subjects, availability of software employed, and instruction and response package. These additional factors limit the ability of other researchers in attempts at repeating this experiment. However, if the construction and administration of this experiment is duplicated exactly as prescribed in this text, replicability should not present a problem.

Sensitivity Analysis

In addition to the two main hypotheses several other investigative type questions will be addressed. Each of these questions serve as sensitivity analysis on the data:

1) Does gender affect decision accuracy?

2) Does gender affect decision confidence?

3) Does graphics training affect decision accuracy?

4) Does graphics training affect decision confidence?

The purpose of the sensitivity analysis, investigative questions, is to determine if the experimental results are sensitive to any of the above identified factors. The first question was proposed as a result of previous research. Several studies have concluded that their results are limited due to a lack of generalizability (Davis, DeSanctis and Jarvenpaa, Dickson, *et al.*).

This study attempts to bridge the generalizability question by using two decision problems. Provided the conclusions from each problem's analysis are compatible, some claim can be made that the results are indeed generalizable. The remaining six factors chosen for the analysis were selected because they seemed to reflect the potential for causal impacts on the hypotheses. Questions two and three arise from work done that indicates gender differences exist in the interpretation of graphical data (MacKay and Villarreal, 1987: 544).

As for questions four and five, it would seem plausible that the more graphics training one has been exposed to, the better one's performance would be in using graphics for decision-making purposes. The level of graphics training was ascertained from each

subject in a post experiment questionnaire completed by each subject following the administration of the experiment. The data collection item for training had the following form:

> Have you ever had any training with graph construction and/or interpretation? (*Circle all that apply*).
>
> a) Yes, formal training on graph construction.
>
> b) Yes, formal training on graph interpretation.
>
> c) Yes, informal training on graph construction.
>
> d) Yes, informal training on graph interpretation.
>
> e) No formal or informal training on graph construction or interpretation.

Each possible response was assigned a numerical rating. Response e) was assigned a value of zero, while responses d), c) ,b), and a) received respective values of 1, 2, 3, and 4. If anyone selected more than one response, the response values were summed to arrive at the subject's training score. The values with respect to responses were chosen as a reflection of the perceived benefit derived from each indicated type of graphic training. Training should indicate an increased ability of a subject to accurately utilize graphical data. As training progresses to more formal and involved levels -- construction training being more intensive than interpretation training -- one can logically postulate that individuals with the greatest amount of training will perform better. That is, those subjects with a higher training score will be able to make accurate decisions without being distracted by background images.

Demographics Questionnaire

A post experiment questionnaire was included the final part of the experimental package. The questionnaire is included in the experimental packages in both Appendices D and E. The purpose of this questionnaire was to collect demographic data. The responses provided by the subjects on the questionnaire provided essential information for performing analysis on the experimental results with respect to the independent variables. The key questionnaire items pertinent to this thesis' hypotheses and investigative analyses included questions:

1. What is your gender?

3. Are you color blind?

4. Have you ever had any training with graph construction and/or interpretation?

10. Based solely on the information provided, how confident one you that you made the appropriate overall, final decision? and

11. Did you have any previous knowledge of this experiment?

Question one is pertinent to performing gender analysis as discussed in investigative question one. Determining if any subjects were color blind seemed prudent since color was used throughout the experiment. If any subjects indicate color blindness, their responses will be checked to determine if the visual challenge hampered their ability to perform the tasks and arrive at the proper decision.

Question four was used to collect the necessary data to perform sensitivity analysis based upon training. This analysis was previously explained above. The method of compiling responses to this question was also explained previously. Question eleven was

included to facilitate the exclusion of any subjects possessing prior knowledge of the experiment's purpose.

Finally, question ten was the avenue of collecting the data necessary to test hypotheses 2, H_{02}. The response options took the form of a 7-point Likert scale. The responses of each subject were recorded. This raw number was used in the analysis to determine if a significant difference exists between the control and experimental groups. H_{02} is designed to test for a difference between the confidence level of subjects whose decision problem contained background graphics and those that were void of background graphics.

Several other questions were included on the questionnaire to provide for possible, future interests in other areas of sensitivity analysis that might arise following the completion of the experimental treatments and manipulations. These additional questions may also aid other researchers interested in the effects of background graphics on decision-making.

Equipment

The administration of the experiment required the use of some specific equipment. This equipment, including software, was chosen to reflect the external environment. The equipment utilized in the experiment is similar to that in use by business and DoD decision-makers.

The graphs were constructed using PowerPoint® 4.0 software running on a Hewlett-Packard Pentium 60 micro-processor. The graphs were projected on the

overhead projector screen using an InFocus® Systems LitePro® 560/570 LCD Projector. This projector was interfaced with a 486 laptop computer. The interface was set to run the PowerPoint® slide show on both the laptop and the projector, which simultaneously projected the graphs onto the screen. The PowerPoint file containing the graphs was copied onto the laptop's c:drive. The file was opened and the slide show was run, utilizing the built-in timings. Microsoft® Word was used to create the package passed out to the subjects. Statgraphics was used to perform the analysis of the collected data. A color printer is necessary to produce the graphs on paper. However, paper copies of the graphs were not provided to the subjects in the experiment. The printing of the graphs was strictly for their inclusion in this thesis text.

Method of Analysis

Analysis of the obtained data was accomplished using the Kruskal-Wallis test. The use of a non-parametric test vis-à-vis a parametric one was due to the nature of the two tests.

> Parametric tests are the more powerful because their data are derived from interval and ratio measurements. Nonparametric tests are used to test hypotheses with nominal and ordinal data. Parametric techniques are the tests of choice if their assumptions are met. (Emory, 1991: 529)

The aforementioned assumptions are five in number:

1. The observations must be independent.

2. The observations should be drawn from normally distributed populations.

3. These populations should have equal variances.

4. The measurement scales should be at least interval so that arithmetic operations can be used with them.

5. The means of these normal and homoscedastive populations must be linear combinations of effects due to columns and/or row. (Emory, 1991: 529-530)

These assumptions must be met for any parametric test results to be valid; that is, conclusive.

In cases where not all of the above assumptions are met, nonparametric tests provide an alternative for evaluating data. For the purposes of this thesis' analysis, the Kruskal-Wallis nonparametric test was used. A nonparametric test was chosen for the following three reasons.

1. Non-continuous data. An overwhelming majority of the response variables were categorized as either 0s or 1s. Thus the data are of an ordinal and nominal nature.

2. The existence of normality is questionable.

3. The existence of equal variances across groups is likewise questionable.

The decision to use a nonparametric test in general and the Kruskal-Wallis test in particular was based upon the nominal and ordinal nature of the collected data. The Kruskal-Wallis test as contained in and employed by the software package Statgraphics® version 7 (for DOS) was utilized. The equations and methodology used in the Kruskal-Wallis test are explained in the Statgraphics® user's manual and elsewhere (Statgraphics, 1993: K-19 - K-23 and Conover, 1980: 229-239).

To perform a Kruskal-Wallis test within Statgraphics®, one selects the analysis of variance option under the models menu. Then select the Kruskal-Wallis Test. Upon making this selection, the input screen appears. Here the response variable data and the sample from which each observation was derived are entered for analysis (Statgraphics, 1993: K-21). Table 4 contains the summary of categories of data that were entered into the software package for performance of the statistical analysis. The data corresponding to the Table 4 categories are provided in Chapter IV.

The numerical and categorical data that were entered into Statgraphics® is provided in Appendix G, while the actual files imported into Statgraphics® is contained in Appendices H and I. The format and procedures for importing data into Statgraphics® is explained in the Statgraphics reference manual (Statgraphics, 1993). The Statgraphics input in Appendices H and I are a consolidation, by decision problem, of the control and experimental group data contained in Appendix G.

The terms in Table 4 are consistent with their use throughout this thesis. Outsourcing and benchmarking refer to the respective decision problems utilized in the experiments. Confidence and Decision represent the response in relation to hypotheses H_{01} and H_{02}, respectively. The response "Decision" was collected after the initial viewing of the graphs. "Reviewed Decision" refers to the response collected following the, one time, review of the graphs.

H_{03} and H_{04} are the respective tests regarding gender and training responses. These responses were gathered using questions 1 and 4 of the demographics questionnaire and are represented as Q1 and Q4. The term "Group," in the table represents the

Table 4. Summary of Data Categories

Decision Problem	Response Variable	Sample
Outsourcing	Confidence	Group
Outsourcing	Decision	Group
Outsourcing	Confidence	Q1 (Gender)
Outsourcing	Decision	Q1 (Gender)
Outsourcing	Confidence	Q4 (Training)
Outsourcing	Decision	Q4 (Training)
Outsourcing	S1	Group
Outsourcing	S2	Group
Outsourcing	S3	Group
Outsourcing	S4	Group
Outsourcing	S5	Group
Outsourcing	S6	Group
Outsourcing	Reviewed Decision	Group
Outsourcing	Reviewed Decision	Q1 (Gender)
Outsourcing	Reviewed Decision	Q4 (Training)
Benchmarking	Confidence	Group
Benchmarking	Decision	Group
Benchmarking	Confidence	Q1 (Gender)
Benchmarking	Decision	Q1 (Gender)
Benchmarking	Confidence	Q4 (Training)
Benchmarking	Decision	Q4 (Training)
Benchmarking	S1	Group
Benchmarking	S2	Group
Benchmarking	S3	Group
Benchmarking	S4	Group
Benchmarking	S5	Group
Benchmarking	S6	Group
Benchmarking	Reviewed Decision	Group
Benchmarking	Reviewed Decision	Q1 (Gender)
Benchmarking	Reviewed Decision	Q4 (Training)

application of background graphics. "Group" includes the experimental and control subjects responses. The terms S1 through S6 denote the responses to the statements on

graphs one through six. The terms are used in identical fashion for each decision problem. The response values for each term are provided in Appendices G, H, and I.

Summary

The methodology used in the design and construction of this experimental study was provided. This methodology incorporated a discussion of the population, the sample, and the equipment used to conduct the experiment. Discussion was also given to the tradeoffs between external and internal validity.

The use of the posttest demographic questionnaire to collect responses for analysis was explained. Also explained was the method used for applying sensitivity analysis to the proposed hypotheses. In addition to the discussion on sensitivity analysis, the method and procedure for analyzing the response data was justified. The Kruskal-Wallis test yielded the results analyzed in the following chapter.

IV. Analysis and Findings

Two decision problems were used in this thesis. Each was independently used to test the effect, if any, of background graphics on decision-making. The data obtained was used to perform analysis with respect to the proposed hypotheses.

The results of the analyses are summarized in the tables below. The subject's responses are recorded in Appendix G. Appendix J contains the statistical output produced by Statgraphics®.

Detailed analysis of each hypothesis is provided. In addition to the analysis and presentation of this work's findings with respect to its formal hypotheses, an excursion into the influence of graph complexity was undertaken. Finally, the results are summarized into three levels of analysis separating the concepts of graph complexity, sensitivity analysis, and the two hypotheses involved.

Hypotheses

The two hypotheses identified to achieve the objectives of this study were:

1. H_{01}: Background graphics do not affect decision accuracy.
2. H_{02}: Background graphics do not affect decision confidence.

The first hypothesis, H_{01}, specifies that the use of background graphics do not influence decision-makers. The second hypothesis, H_{02}, asserts that decision-makers are equally confident of a decision's accuracy regardless of the existence of background graphics.

In addition to the null hypotheses, several areas for sensitive analyses were identified. These areas were treated as investigative questions and referred to as hypotheses three and four.

3. H_{03}: Gender does not affect H_{01} or H_{02}.

4. H_{04}: Graphics training does not affect H_{01} or H_{02}.

Additionally, attention was given in the study's design to make generalization across decision problems a viable activity.

Experimental Results

The results of the statistical analyses are provided in Tables 5 and 6 along with the raw data associated with each response variable. The raw numbers indicate the number of correct responses, save in the case of confidence. The confidence number is the sum of the subject's responses to question ten on the demographics questionnaire.

Table 5 contains the raw data collected from the outsourcing decision problem accompanied by the associated statistical results.

Table 5. Summary of Outsourcing Raw Data with Results

Response Variable	No Background	Percent Correct	Background	Percent Correct	p-value
Decision	24	82.76%	23	74.19%	.312401
Reviewed Decision	20	68.97%	26	83.87%	.761708
Confidence	5.21	-	5.20	-	.857429

The analysis for each decision problem will be done separately beginning with that for the outsourcing decision problem. With respect to H_{01}, the resulting p-value was .312401;

therefore H_{01} is not rejected. Likewise, H_{02} is not rejected based upon a p-value of .857429. The inability to reject either of the null hypotheses supports the claim that background graphics do not affect decision accuracy or confidence in a decision.

The results were not sensitive to gender and training. The p-values for subject confidence as impacted by their gender and training are lower than those for decision accuracy, but still insignificant. Although claims exist that gender can make a difference, this finding is not at all surprising. The results proclaiming that graphics training has no effect on decision accuracy or confidence are somewhat surprising, especially at the level indicated by this analysis.

The analysis of the benchmarking problem's data yielded analogous conclusions with respect to the hypotheses. The raw data is provided in Table 6. A p-value of .563561 precluded the rejection of H_{01}. H_{02} was not rejected based on a .409316 p-value. The inability to reject either of the null hypotheses, based upon their insignificant p-values, supports the claim that background graphics do not affect decision accuracy or confidence in a decision.

Table 6. Summary of Benchmarking Raw Data with Results

Response Variable	No Background	Percent Correct	Background	Percent Correct	p-value
Decision	36	87.81%	42	91.30%	.563561
Reviewed Decision	37	90.24%	39	84.78%	.85641
Confidence	5.35	-	5.20	-	.409316

With respect to the gender and training sensitivity testing, each was shown to have no effect on confidence or decision accuracy. Decision accuracy as a response to gender

yielded a p-value of .959865; a p-value of .186988 was obtained in relation to decision confidence. Decision accuracy tested against training with a p-value of .829885. The confidence response approached an acceptable level, but at .0888819 is outside a 95% confidence level.

Given that the initial decisions did not lead to the rejection of any of the proposed hypotheses, allowing for decision-makers to change incorrect decisions to correct ones could not change the conclusions of the analysis. In fact, the results of these tests show an increase in the p-values. This increase was expected since those subjects with incorrect decisions would use the second opportunity of viewing the graphs to rectify their mistake.

Based on the comments garnered in the pilot study, the possibility exists that some decision-makers (subjects) became so absorbed in the data extraction tasks on each graph that they forgot the true task at hand. Becoming so immersed in the individual graphs, they might not have interpreted the information in terms of the decision problem. The review portion of the experiment was meant to compensate for this potentiality. The real intent was to provide explanatory ability in the event that the initial decision tested significant and the review insignificant.

In comparing the p-values of each of the benchmarking problem's hypotheses and sensitivity cases, all save one showed an increase from the initial decision to the review. The p-value for gender decreased from .959865 to .808978. This decrease between males and females was attributable to twice as many of the former changing to the incorrect response. This happenstance widened the difference in responses between males and females.

A similar widening of differences also occurred between the initial and reviewed decisions on the outsourcing decision problem. The initial p-value dropped from .630425 to one of .315256 for the reviewed decision. However, in the outsourcing problem more males changed to the correct decision while four times as many females reversed their correct decision upon review.

Taken together, the results of the two parallel experimental designs indicate that background graphics have no effect on decision-making ability. The subjects in the study were equally able to process the information contained in the graphs irrespective of the existence of background graphics. The presence of pictures and color schemes did not hinder the decision-maker's ability to rationally decide upon a course of action, *i.e. make the appropriate decision*.

The results of the analysis are consistent for both decision problems, providing some support for the proposal that the results of the analysis are generalizable across decision problems. However, for this conclusion to be definitive, further parallel experiments should be conducted. The preliminary indications would imply that it is possible to generalize across decision-making problems when addressing subjects dealing with the use of background graphics.

Graph Complexity

The issue of complexity, in relation to graphs, was introduced in Chapter II. Davis' research into issues of complexity was discussed previously and a critique of his article dealing with the subject is provided in Appendix A. Although this study was not

initially designed with complexity in mind, the attempt was made to analyze the data in this vein. The response data obtained (Appendix G) for each graph statement, *whether the subject agreed or disagreed*, was analyzed. The raw data, indicating the number of correct responses, for the statement on each graph are contained in Tables 7 and 8. Also included in the tables are the statistical results of the analysis comparing graph responses to background graphics application. These p-values represent the following complexity hypothesis:

H_C: Background graphics do not affect complexity.

This hypothesis should be interpreted to mean that background graphics do not compound the complexity of a graph.

The rationale for an analysis of complexity within this study's design exists in the fact that each decision problem's graphical presentations had a mixture of graphs, some of which were more complex that others. In the outsourcing decision problem, graphs one and two are more complex than three through six. See Appendices B and F for visual verification and graph titles, respectively. The response to each of the six graphs' statements is represented in Table 7 as S1 through S6. The p-values for S1 and S2 indicate that one is not significant and two has some significance. However, for H_C to be

Table 7. Complexity and Outsourcing Graphs

Response Variable	No Background	Background	p-value
S1	21	19	.273322
S2	29	27	.047179
S3	29	28	.0726449
S4	21	18	.175659
S5	28	28	.304231
S6	15	12	.137885

rejected, both should test significant. Additionally, S3 tests significant if the 95% confidence level being used here is relaxed slightly, while the companion non-complex graphs show no significance.

For the benchmarking decision problem, graphs 1, 2, and 3 are complex. S1 through S6 in Table 7 represent the responses to each of the six graphs' statements.

Table 8. Complexity and Benchmarking Graphs

Response Variable	No Background	Background	p-value
S1	35	38	.728335
S2	36	40	.905936
S3	25	39	.0124535
S4	38	38	.17323
S5	36	42	.594775
S6	36	46	.0152843

The analysis has analogous results to that immediately above in the outsourcing problem. Two of the three complex graphs' responses show no effect while S3 indicates an effect. Again mirroring the above results, the non-complex graphs have one response, S6, that tests significant. These results do not coincide with the hypothesis. The more complex graphs should show a significant difference between those with background graphics and those without them. The significant result in S6 compounds the issue, as it is not considered one of the complex graphs.

Given the inconsistent and thus inconclusive p-values, H_C cannot be rejected. Therefore, no conclusion can be reached concerning the relationship between background graphics and complexity.

Summary of Analysis

The primary analysis was done on the two hypotheses that background graphics do not affect decision confidence or accuracy. The results of this analysis precluded the rejection of the null hypotheses. This conclusion was reached for both decision problems.

On a secondary level, sensitivity analysis was done to determine if gender or training impacted the two primary hypotheses. The analysis suggested that neither gender nor training influences decision accuracy. Again, this conclusion was reached for both decision problems.

A tertiary analysis was accomplished using the concept of complexity. The results of this analysis proved to be inconclusive.

V. Conclusion

Background graphics are a readily available means of adding color and pictures to graphic, as well as nongraphic, presentations. Opinions differ as to whether background graphics serve an enhancing role, a hindering one, or no role at all in the decision-making process. The addition of color schemes and pictures add more ink to the graphs, surrounding the informative data with eye catching images. Some people prefer the use of these aesthetics while others take offense. The two anecdotes included in the introduction to this thesis serve to illustrate the opposing points of view.

Can the use of background graphics influence the decision-making process? This possibility was the central theme of this study. Background graphics has this potentiality. The decision produced by a presentation is dependent upon two main factors: the believability -- the confidence in the information provided -- and the accurate interpretation of the data. Therefore, the preparation of graphical data should attempt to convey the required information without distracting the decision-maker.

Summary of Results

A review of the graphics literature revealed few studies that focused on graphics versus decision-making and no specific research into the effects of background graphics. The bulk of previous graphics research dealt extensively with the use of graphs versus tables for displaying information. The cumulative results of previous research efforts have

been inconclusive. The use of graphics has been limited to the graphical display of information. This study expanded the use of graphics to included all types of graphical pictures, icons, and color schemes available for incorporation into presentations.

One hundred forty-seven PCE students participated in the experiments to determine if decision-makers are affected by background graphics. Two decision problems were used independently of each other to test for effects on decision-making caused by background graphics. Tables 5 and 6 contain the results of the analyses. The results of the study show no effect caused by background graphics.

Impact on the DoD

Given the hierarchical nature of DoD decision-making, the decisions made by lower level managers impact those at higher levels; presentations are made to each successive layer of the hierarchy. Many of these presentations contain some form of background graphic. Often the briefed become the briefers at the next level, thus delivering the presentation format and graphics to increasingly important decision-makers. Therefore, the information presented to decision-makers at all levels should be free of influential factors that are not directly pertinent to the decision at hand.

The results of this study indicate that the use of background graphics does not hinder the ability of decision-makers to reach accurate decisions and reach them with confidence. These results are pertinent to decision-makers at all levels of the DoD decision-making hierarchy. The results indicate that presentations using background graphics do not affect the outcome of the decision-making process. However, the results

contained herein are from only two experiments, possessing identical design. While the results suggest generalizability across decision problems or environments is possible, more conclusive research needs to be done to confirm these results.

Further Research Recommendations

Several areas for further research became apparent during the course of this study of graphics. While this study continued to utilize some data extraction in conjunction with the attempt to test decision-making, future research should sever the link established herein. One suggestion is attempting to mirror this work's goal without the statements on each graph. The only response required from the subjects would be the decision. This decision could come after extensive viewing of graphs related to some decision problem. Eliminating the data extraction task associated with each graph would exclude the respondent's need to focus on each graph. This elimination of the extraction task might more closely emulate the external decision-making environment.

Another area worthy of study is the decision style of the decision-maker. To accomplish this study, a personality type indicator could be given prior to an experiment and subsequently compared to the response to see if decision style influences decision-making. A focus of this nature would place the study in the general area of studies done on risk behavior. The risk level indicated by a pre-administered test could be coupled with decision options involving graduated levels of risk. Thus decision style and risk avoidance could be directly related to the decision-making process.

Additional research could also be done on the subject of complexity. Even though the preliminary results of this thesis' analysis was inconclusive, a proper experimental design incorporating questions of complexity in its hypotheses would stand a better chance of significant findings. The analysis herein accomplished with regard to complexity was done as an interesting factor, not as part of the deliberate design. Designing an experiment around the issue of complexity would be a worthy pursuit.

Appendix A. Article Critique

A critique of Larry R. Davis' article "Report Format and the Decision Maker's Task: An Experimental Investigation," *Accounting, Organizations and Society*, Volume 14 Number 5/6 1989: 495-508.

Executive Summary

This critique summarizes and evaluates Davis' experimental investigation into the question whether a particular report format is a function of the task required of a decision-maker. To investigate Davis invents two constructs: (1) *efficiency* of different forms of presentation and (2) the *effectiveness* with which information is presented to the decision-maker. He formulates two hypotheses to test his concept of format and task. The results of the statistical analysis of the experimental responses precludes rejection of his hypotheses. In fact he identifies an interaction between the two which implies that the relative *efficiency* and *effectiveness* of differing forms of presentation are affected by the question (task) with which the decision-maker is confronted. The results show that the task (decision problem or question) and the form it is presented in interact to affect the decision-maker's performance-- the time and accuracy with which he completes the task. Additionally, Davis concludes that no one particular form of problem presentation is best for all decision situations.

Critique

This critique examines Davis' experimental study concerning report formats and the decision-maker's task. I will attempt to summarize his key concepts, constructs, results, and his findings. Additionally, I will point out the areas that seem to overlook items of import. Specific criteria for evaluation include reasonable steps in logic: do the ideas flow logically and are they logically exhaustive, meaning all logical explanation are considered; does his experiment adequately weigh the threats to both internal and external validity?

"The objective of this study is to investigate whether the information which a decision maker wishes to extract from an information presentation is a task characteristic which affects the appropriateness of different report formats." (Davis, 1989: 496). Davis defines the task in terms of the questions to be answered. The task could be simple data extraction from a graphical presentation: Which company had the highest gross profits in 1995? Or the task might be a complex decision problem: Based on the information provided in the graphical presentation, should we continue to make this product or should we contract its production. Performance is then measured by the amount of time taken to answer the questions, *i.e. the time to complete the task.*

To test the concept that performance is a function of both time and accuracy, Davis adopts a construct utilizing both the *efficiency* of different forms of presentation to differing tasks and the *effectiveness* of communicating information to a decision-maker via graphic forms versus other methods (tabular, report text, etcetera). Two hypotheses were designed to test these constructs:

> H_1: The form of presentation which allows a question to be answered in the least amount of time will be different for questions of different levels of complexity.
>
> H_2: The form of presentation which results in the most accurate answers to a question will be different for questions of different levels of complexity. (Davis, 1989: 498).

Davis chose a laboratory experiment to conduct this study, testing the above two hypotheses. Thirty MBA students participated, one at a time, making this a cross-sectional sample.

The experiment itself is "A full-factorial, within-subject experimental design...; each subject receives all twenty experimental treatments (five questions manipulated over four forms of presentation) in a different random order." (Davis, 1989: 498). The questions are financial in nature, accompanied by various graphs that contain the question's answer. The design of the experiment appears to be valid. Internal validity is supported in that: (1) the instrument does seem to measure what it purports to measure, (2) the differences in responses (measures) reflect true differences, and (3) the instrument is a structured one and research (Abdolmohammadi & Wright, 1987) indicates that the performance of the sample students are representative of real world decision-makers, utilizing this type of financial data and reaching similar answers.

The variables consisted of one control, two independent, and two dependent; the control variable was the information set. The two independent variables consisted of the form of the presentation and its corresponding question. The dependent variables were

the time the decision-maker needed to answer a question and the accuracy with which he did so.

The responses were analyzed with multivariate analysis of variance. The results show that "there is at least one significant effect." (Davis, 1989: 501). The model utility tests for the hypotheses

> Show that both the main and interactive effects of the question to be answered and the form of presentation are significant. This is true regardless of whether performance is measured in terms of the time required to answer the question or the accuracy of the question-answers. (Davis, 1989: 501).

The results support the contention that the form of a presentation and the question to be answered (the task) both have an effect on the performance of a decision-maker. Another important result was seen in the interactive effects; this interaction implies that the relative *efficiency* and *effectiveness* of differing forms of presentation are affected by the question (task) with which the decision-maker is confronted. Furthermore, this implies that no one mode of presentation is better in all decision tasks. Certain graphics may better aid decision-makers with one type of task, while other graphical methods will benefit a different question's resolution. In Davis' words, "...the most appropriate form of presentation... was different for different questions and support both hypothesis 1 and hypothesis 2." (Davis, 1989: 502).

Davis' conclusion states "The results indicate that the most appropriate method of presenting financial information is dependent on the decision-maker's question; different forms of presentation are most appropriate for different questions." (Davis, 1989: 504).

The conclusion that different forms of presentation are best for differing tasks seems valid for the generic financial data used in this particular experiment; however, the generalizability of such a study is limited to the types of financial presentations and questions it represents.

While the design of the study is its strength, its weakness is generalizability. The strength of its internal validity was previously discussed. External validity is apparent in that the type of tasks and graphs used are prevalent in business and industry. However, the conclusion drawn by Davis, as indicated by the study, is not generalizable across all types of data extraction and decision problems. This weakness is important and goes directly to the studies external validity. Davis' results should be considered tentative. Further studies should attempt to broaden the scope of graphic presentation as it relates to decision tasks. Until that time no general statements about the appropriateness of different presentation formats may be made.

References

Abdolmohammadi, M. & Wright, A. "An examination of the effects of Experience and Task Complexity on Audit Judgments," *The Accounting Review*. January 1987: 1-13.

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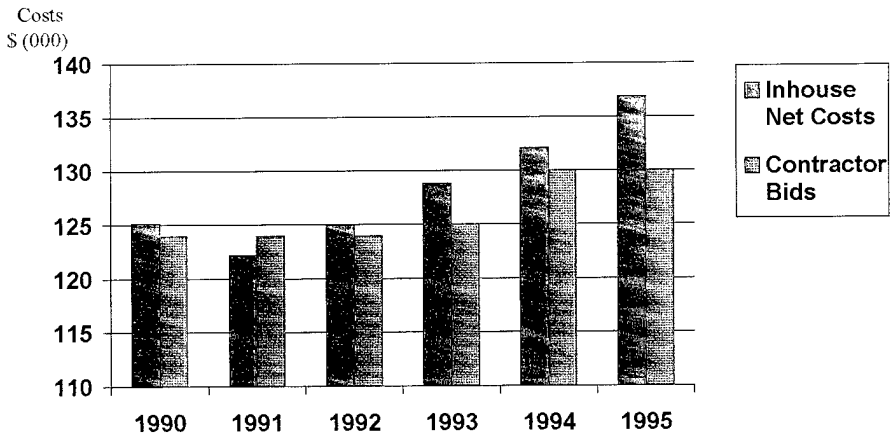
Control

Outsourcing Decision

In-house Net* Costs vs. Contractor Bids

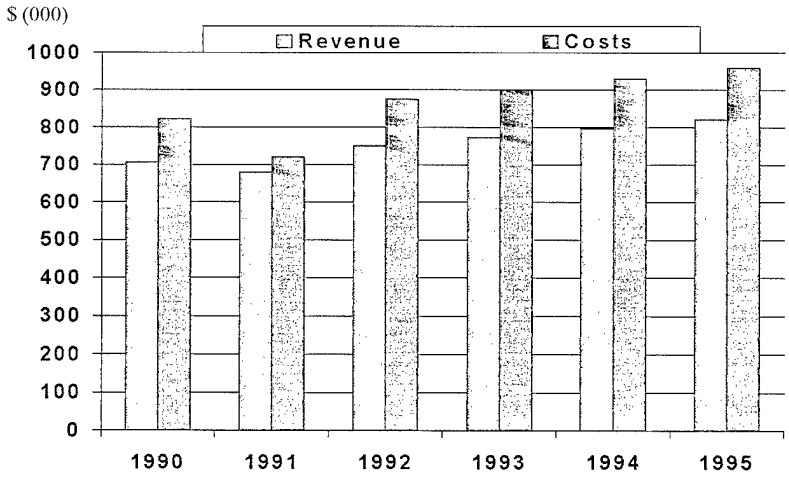
*Net = difference between revenue and costs.



The contractor has underbid our costs every year.

Disagree Agree

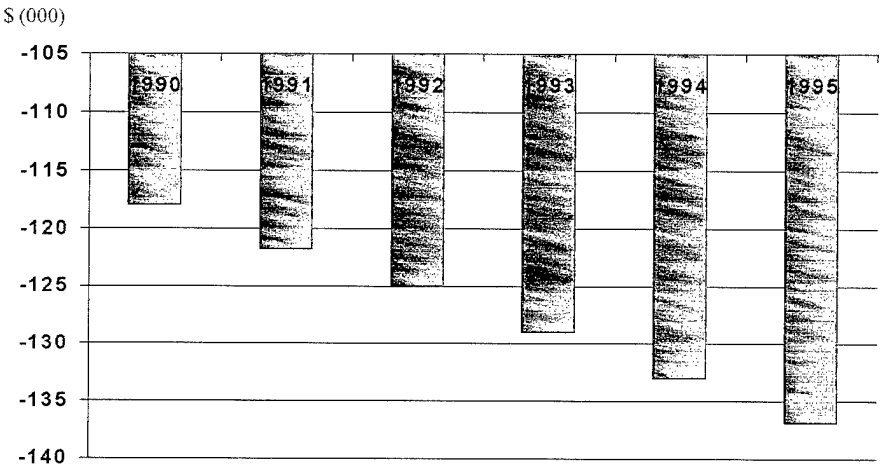
Total Revenue vs. Total Costs



Total costs have exceeded total revenue for each of the past six years.

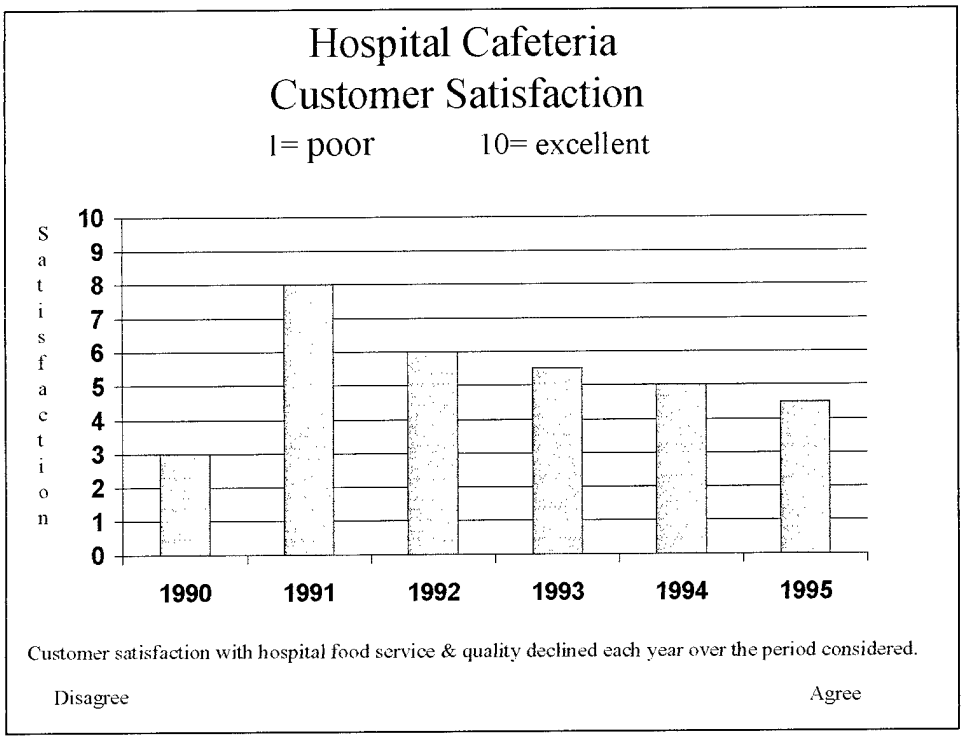
Disagree Agree

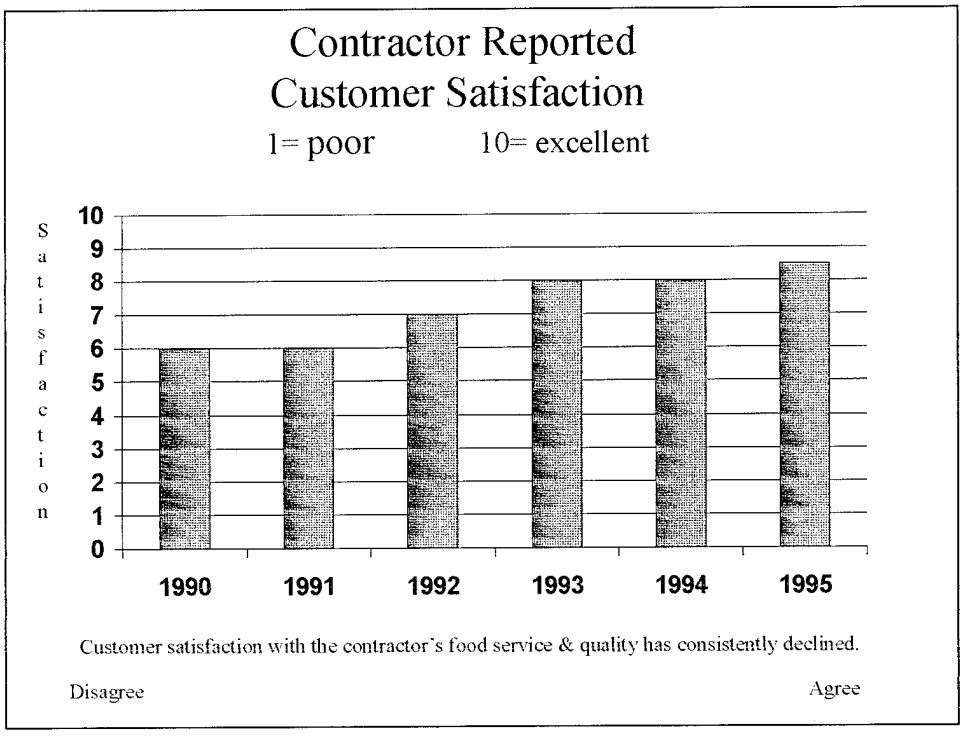
Profit and Loss (P&L)



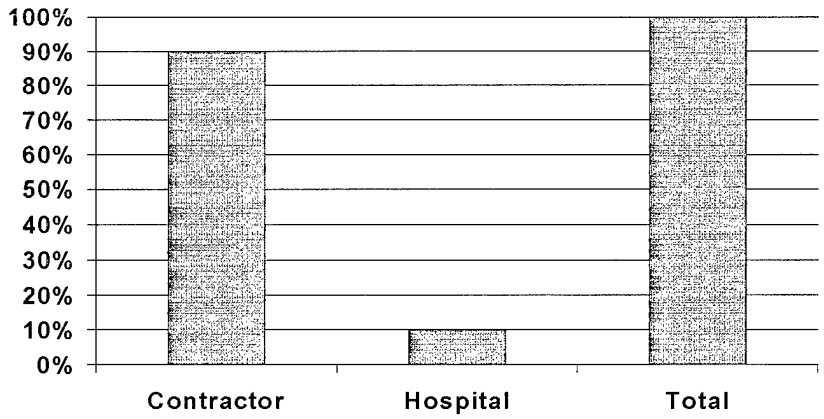
The hospital food service has sustained increased losses over the past six years.

Disagree Agree


Hospital Cafeteria
Customer Satisfaction
1= poor
10= excellent
Satisfaction
10
9
8
7
6
5
4
3
2
1
0
1990
1991
1992
1993
1994
1995
Customer satisfaction with hospital food service & quality declined each year over the period considered.
Disagree
Agree


Contractor Reported
Customer Satisfaction
1= poor
10= excellent
Satisfaction
10
9
8
7
6
5
4
3
2
1
0
1990
1991
1992
1993
1994
1995
Customer satisfaction with the contractor's food service & quality has consistently declined.
Disagree
Agree

Percentage of Cafeteria Employees Retained by the Contractor and the Hospital if the Food Service Function is Contracted Out



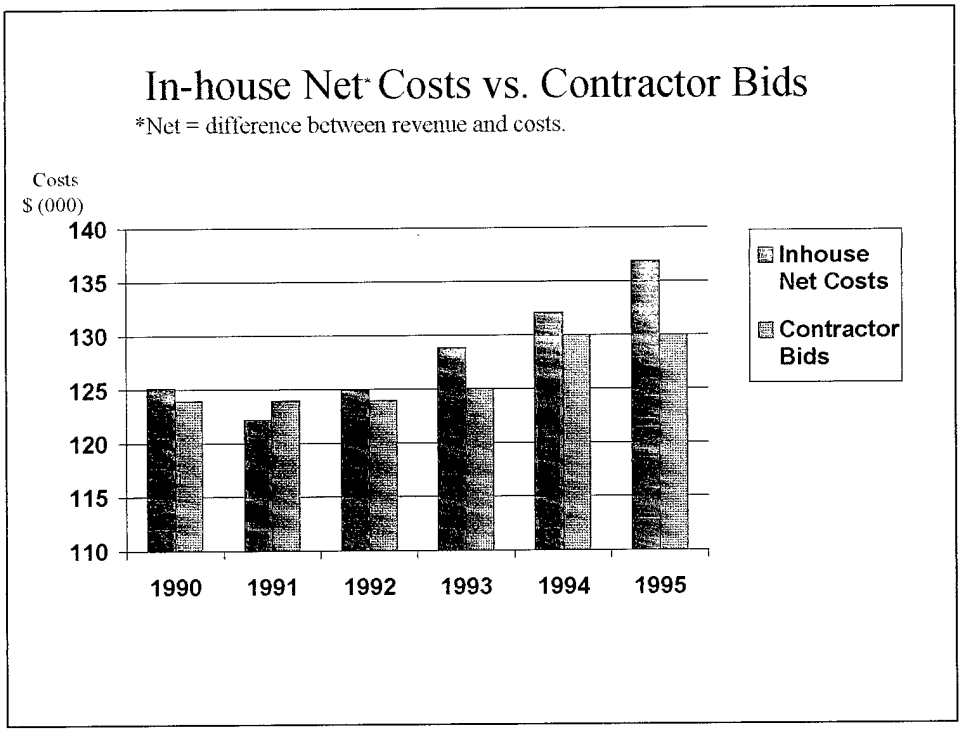
No employees would lose their jobs as a result of contracting out the food service operation.

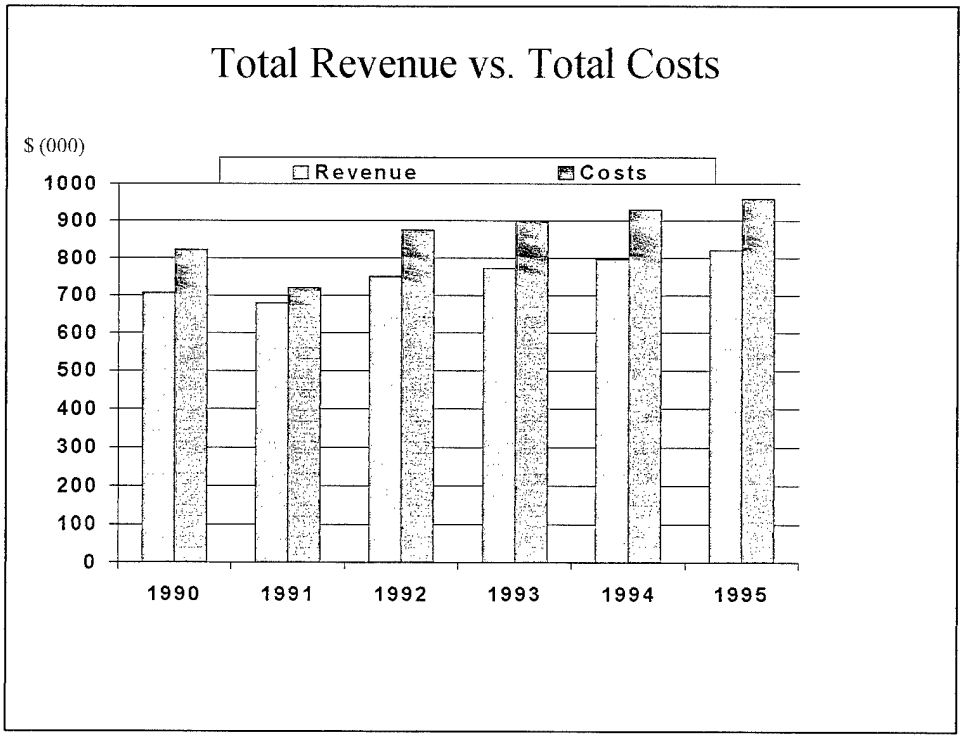
Disagree Agree

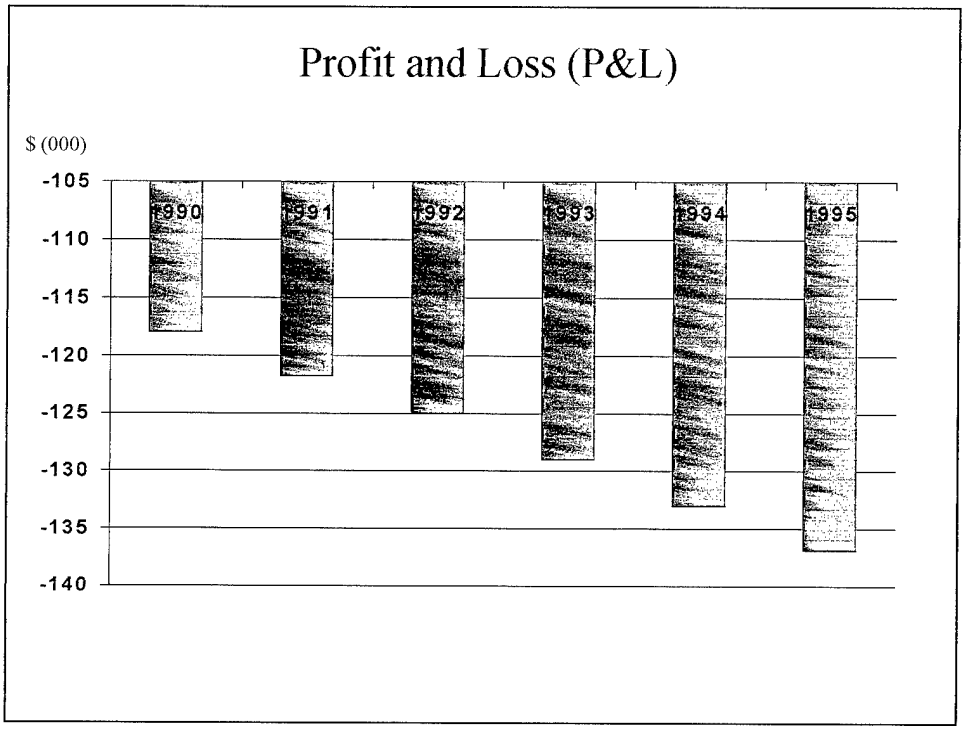
Based solely on the information provided, should the Food Service operation be contracted out?

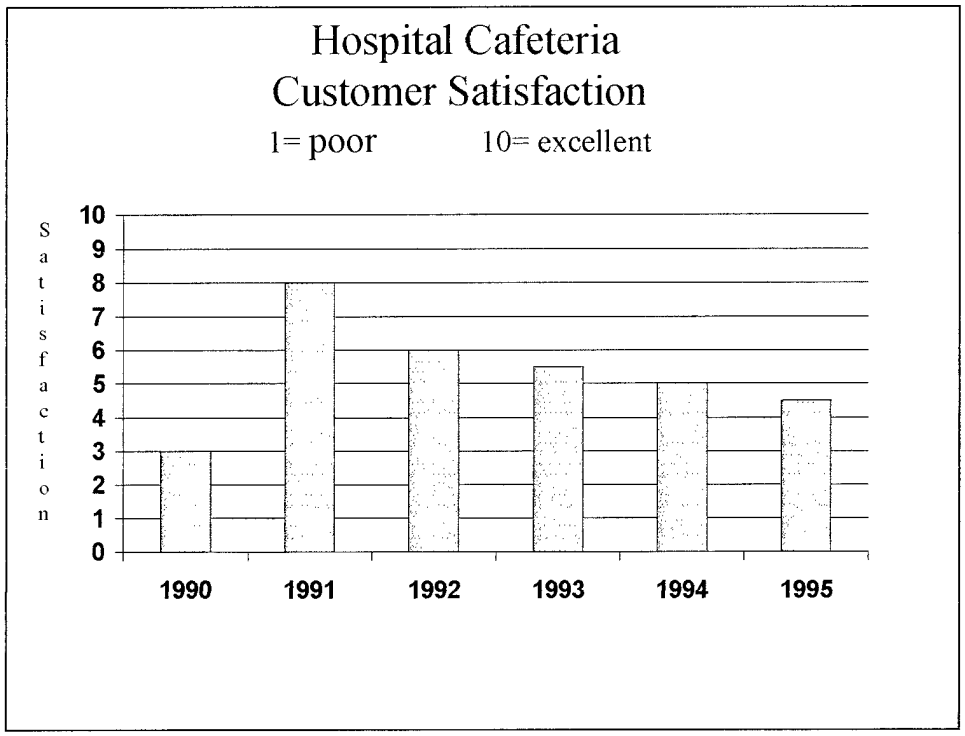
No Yes

Without changing any of your previous responses, you may review the six graphs. The graphs will be shown again in the same sequence as before. Again, please *do not* change any of your previous responses.




Total Revenue vs. Total Costs
$ (000)
Revenue
Costs
1000
900
800
700
600
500
400
300
200
100
0
1990
1991
1992
1993
1994
1995


Profit and Loss (P&L)
$ (000)
-105
-110
-115
-120
-125
-130
-135
-140
1990
1991
1992
1993
1994
1995


Hospital Cafeteria
Customer Satisfaction
1= poor
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Satisfaction
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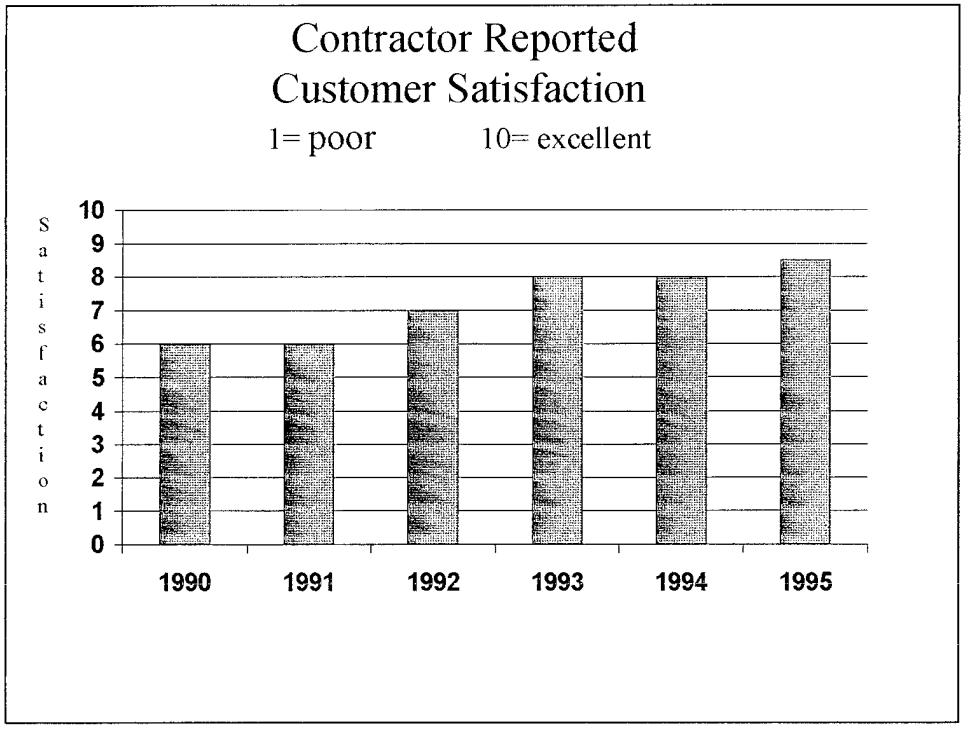
3
2
1
0
1990
1991
1992
1993
1994
1995


Contractor Reported
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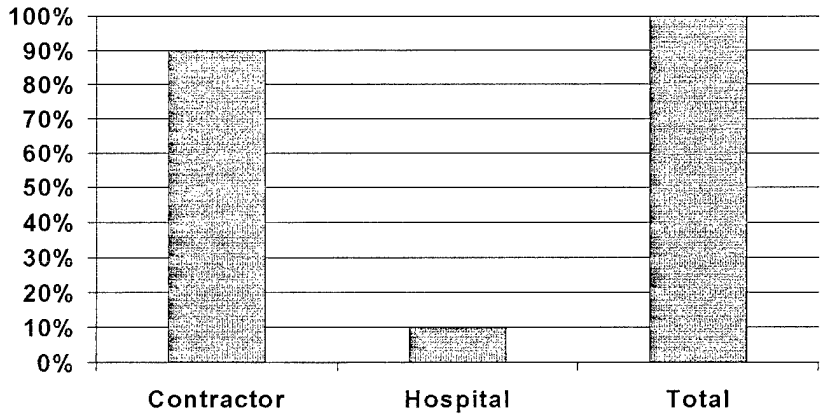
Percentage of Cafeteria Employees Retained by the Contractor and the Hospital if the Food Service Function is Contracted Out

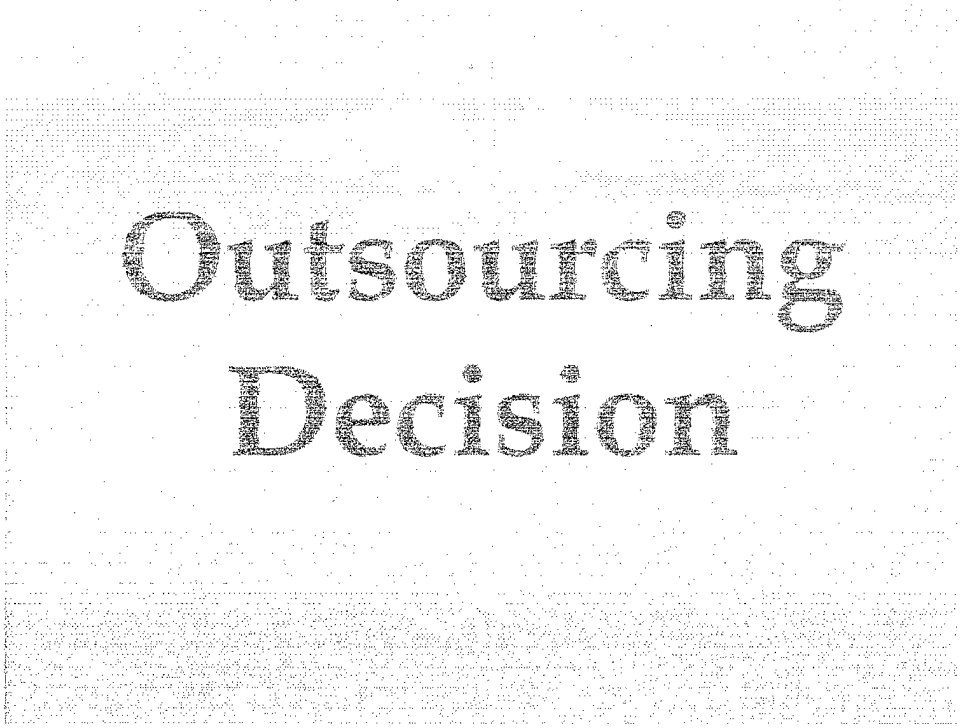


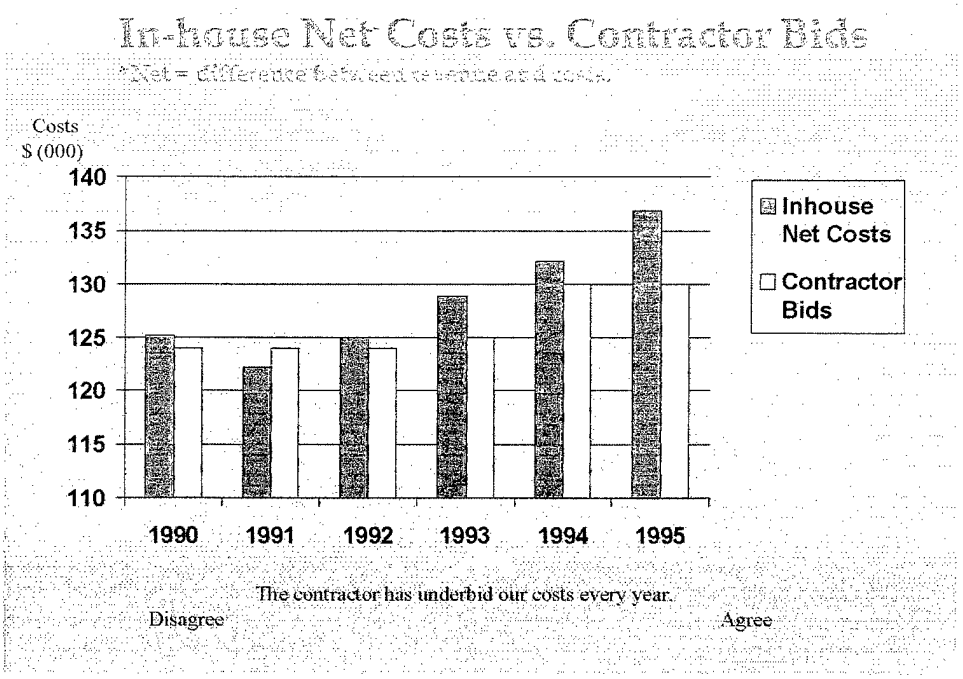
Based upon your review of the graphs, would you make the same decision?

No Yes

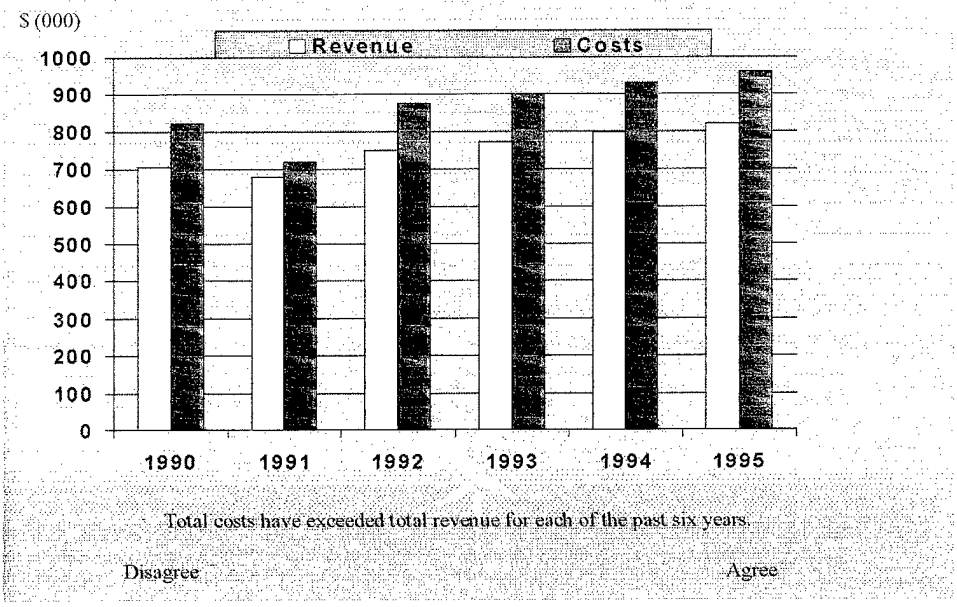
Please complete the attached survey and return the entire package.

Thank you.


Outsourcing
Decision


In-house Net Costs vs. Contractor Bids
Costs
$ (000)
140
135
130
125
120
115
110
1990
1991
1992
1993
1994
1995
Inhouse Net Costs
Contractor Bids
The contractor has underbid our costs every year.
Disagree
Agree

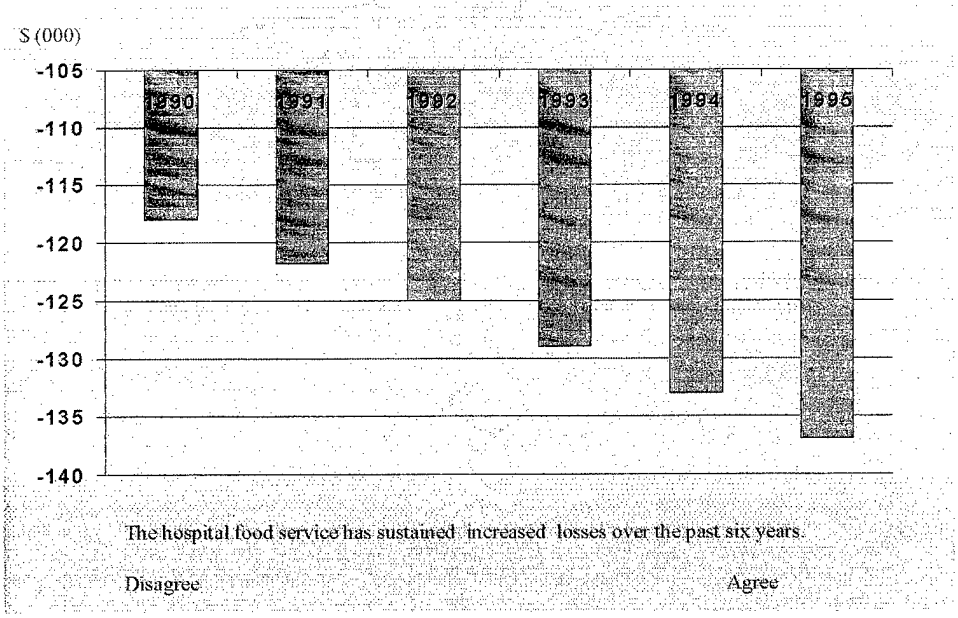
Total Revenue vs. Total Costs



Total costs have exceeded total revenue for each of the past six years.

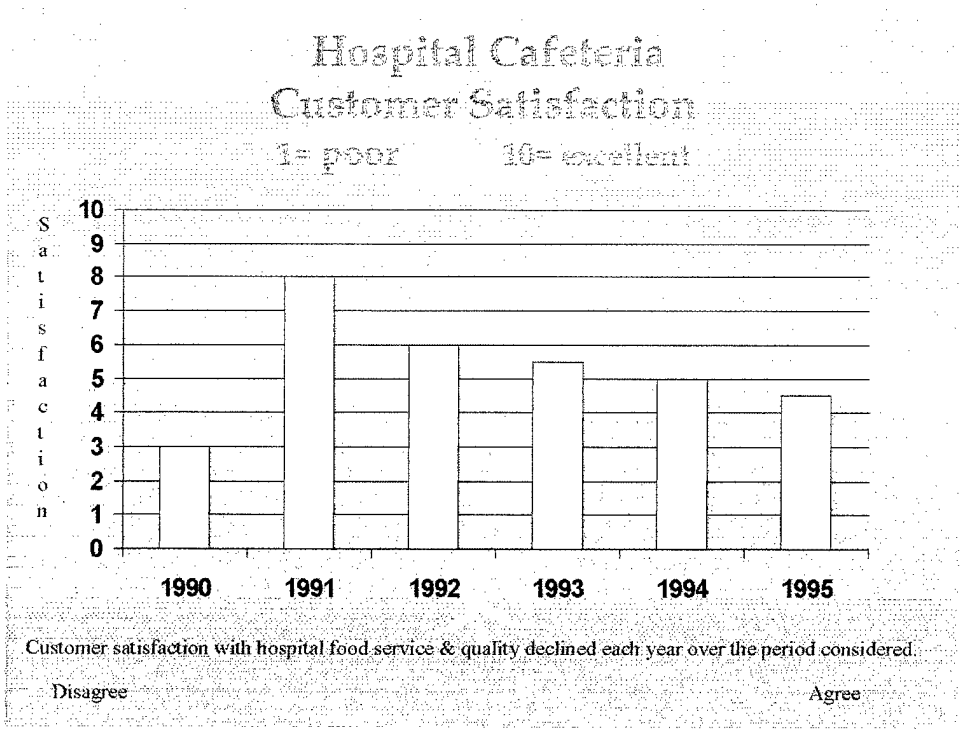
Disagree Agree

Profit and Loss (P&L)



The hospital food service has sustained increased losses over the past six years.

Disagree Agree


Hospital Cafeteria
Customer Satisfaction
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1990
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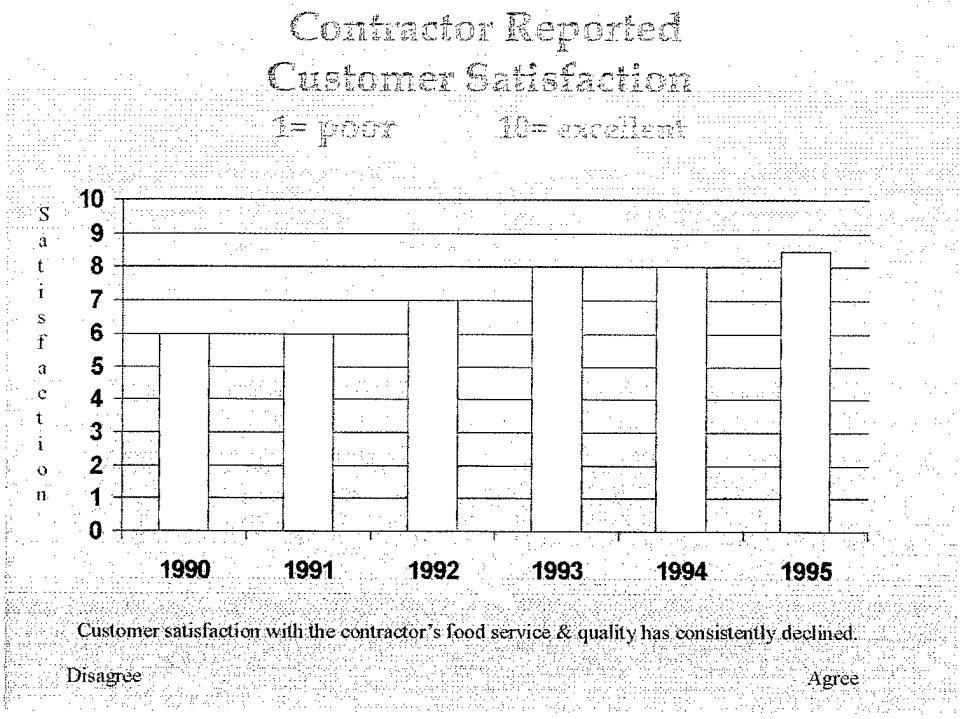
1994
1995
Customer satisfaction with hospital food service & quality declined each year over the period considered.
Disagree
Agree


Contractor Reported
Customer Satisfaction
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Satisfaction
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0
1990
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1992
1993
1994
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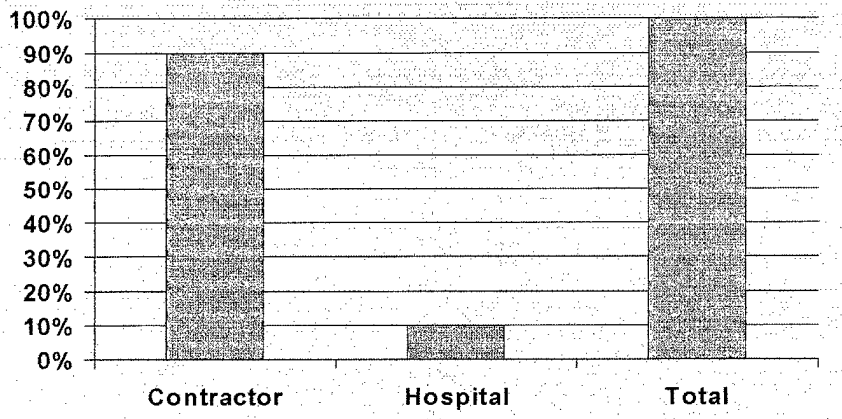
Customer satisfaction with the contractor's food service & quality has consistently declined.
Disagree
Agree

Percentage of Cafeteria Employees Retained by the Contractor and the Hospital if the Food Service Function is Contracted Out



No employees would lose their jobs as a result of contracting out the food service operation.

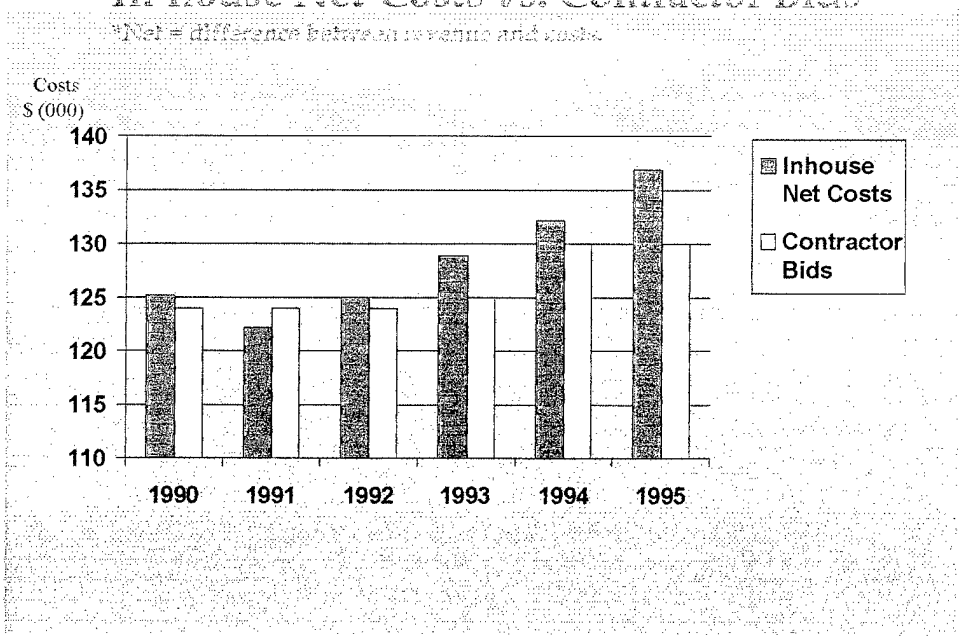
Disagree Agree

Based solely on the information provided, should the Food Service operation be contracted out?

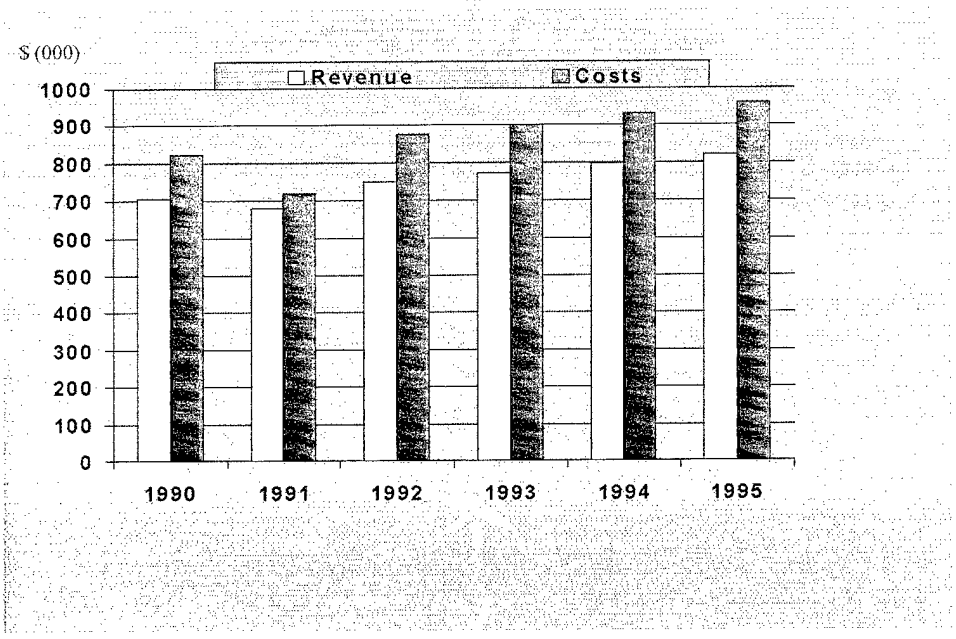
No Yes

Without changing any of your previous responses, you may review the six graphs. The graphs will be shown again in the same sequence as before.

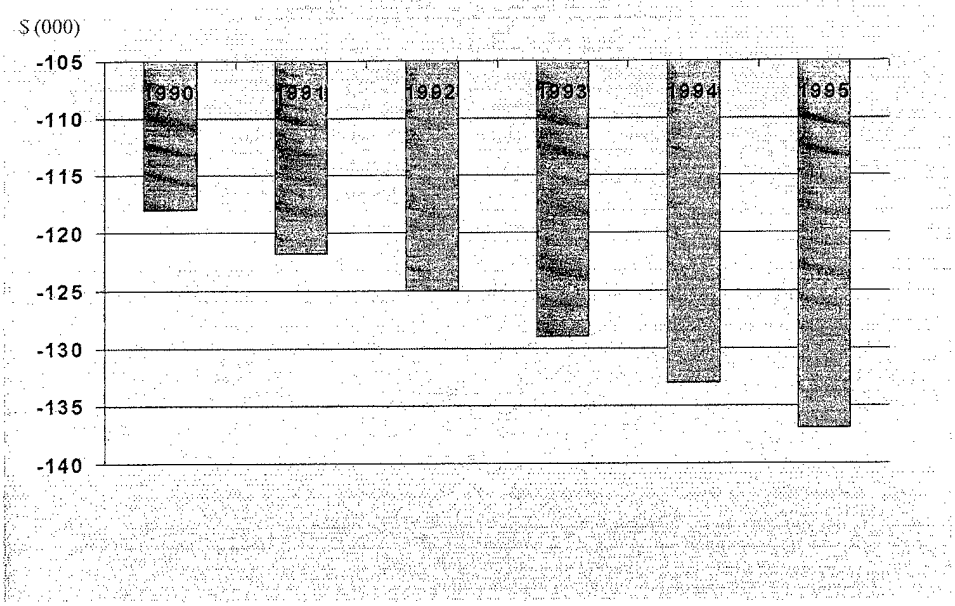
Again, please *do not* change any of your previous responses.

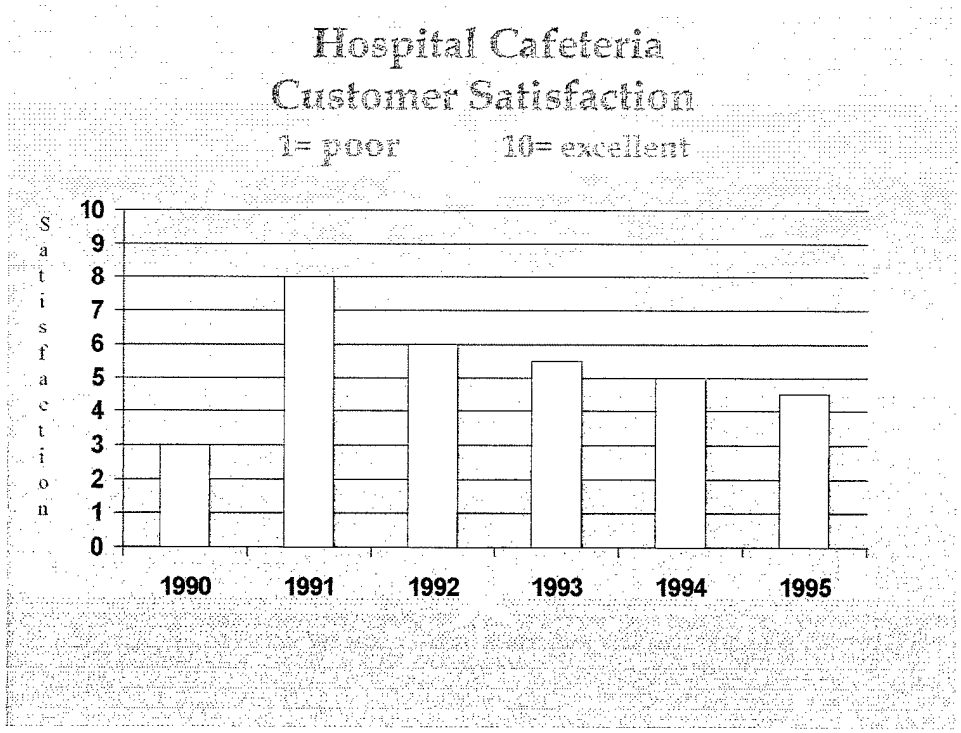


Total Revenue vs. Total Costs



Profit and Loss (P&L)




Hospital Cafeteria
Customer Satisfaction
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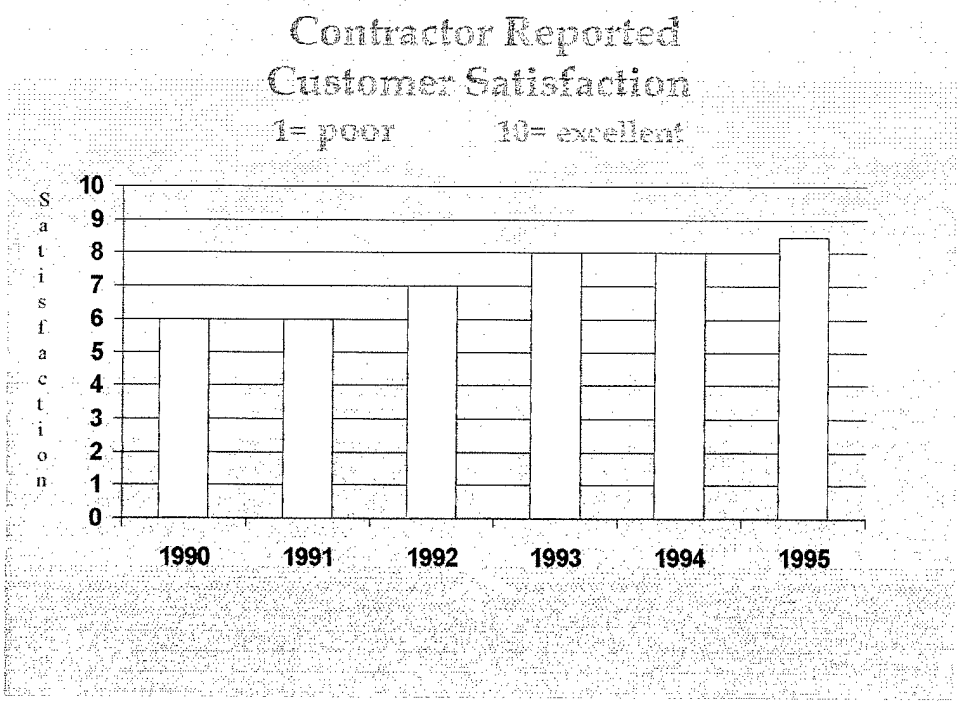
1995


Contractor Reported
Customer Satisfaction
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1990
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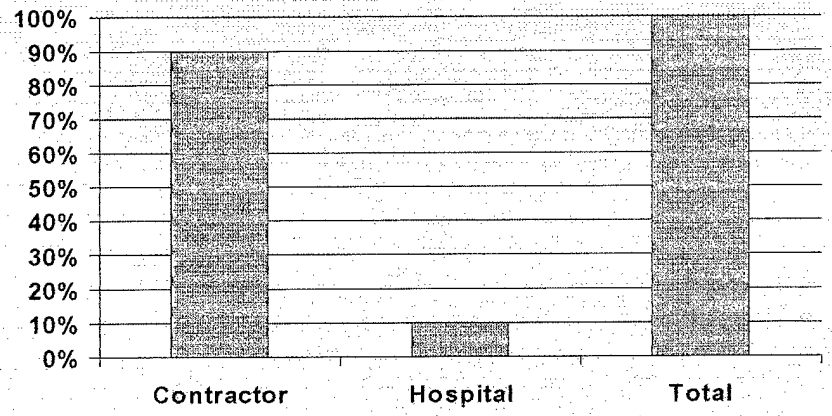
Percentage of Cafeteria Employees Retained by the Contractor and the Hospital if the Food Service Function is Contracted Out



Based upon your review of the graphs, would you make the same decision?

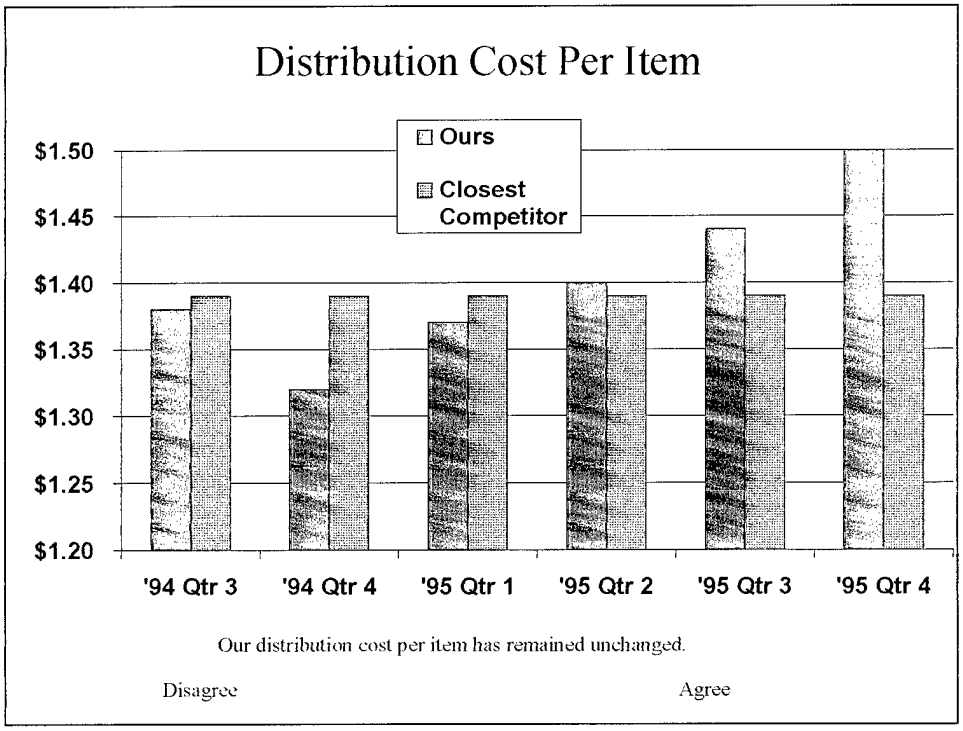
No Yes

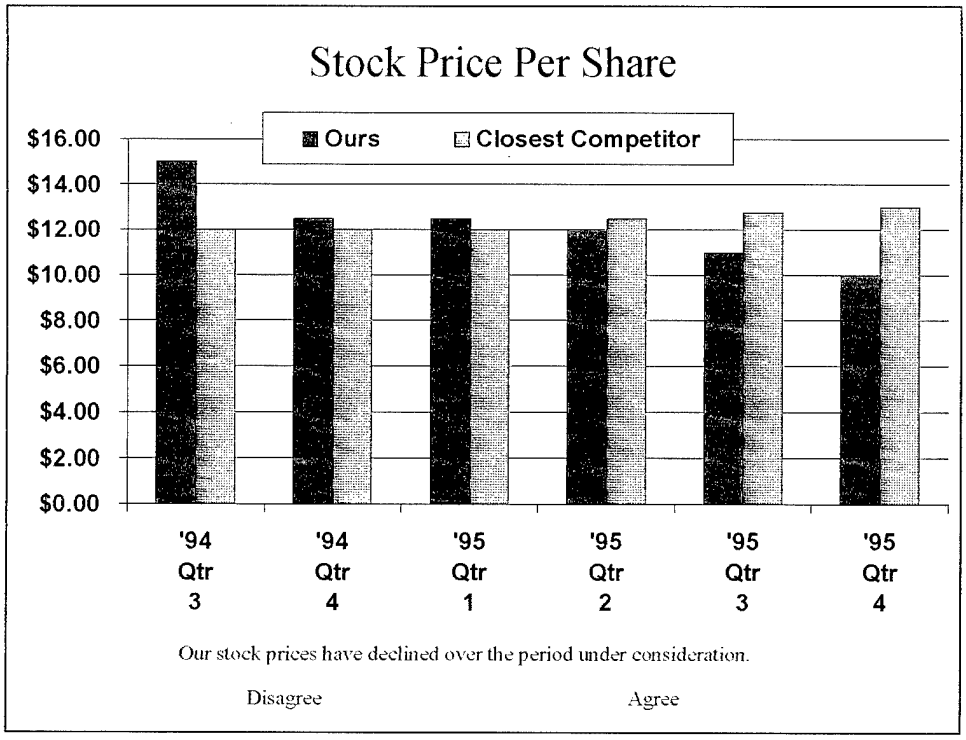
Please complete the attached survey and return the entire package.

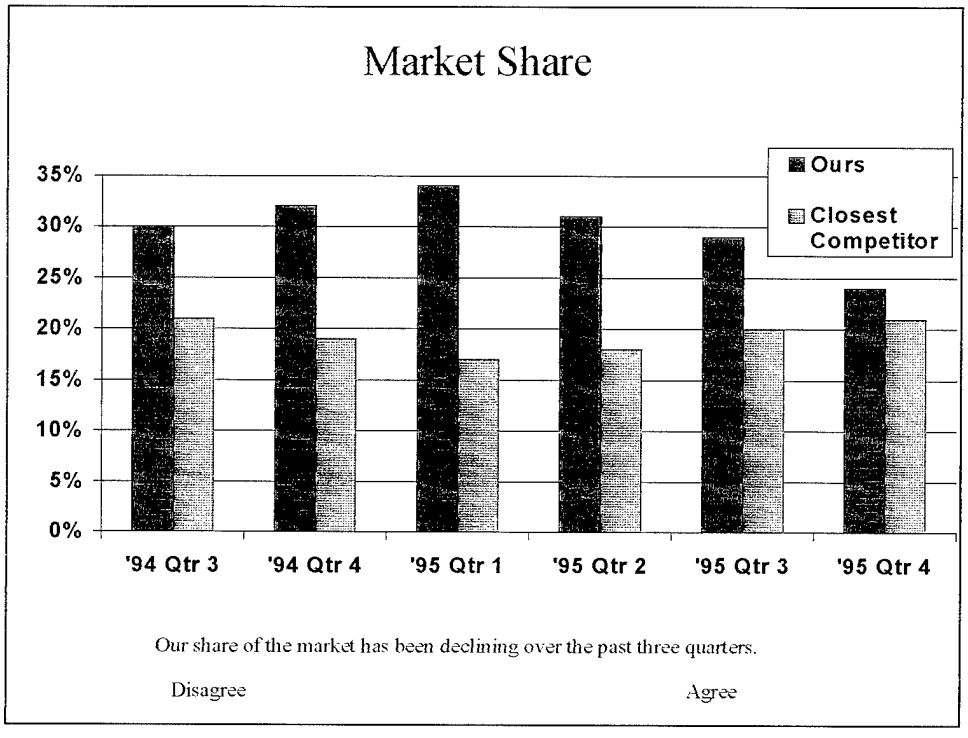
Thank you.

Control

Benchmarking Decision

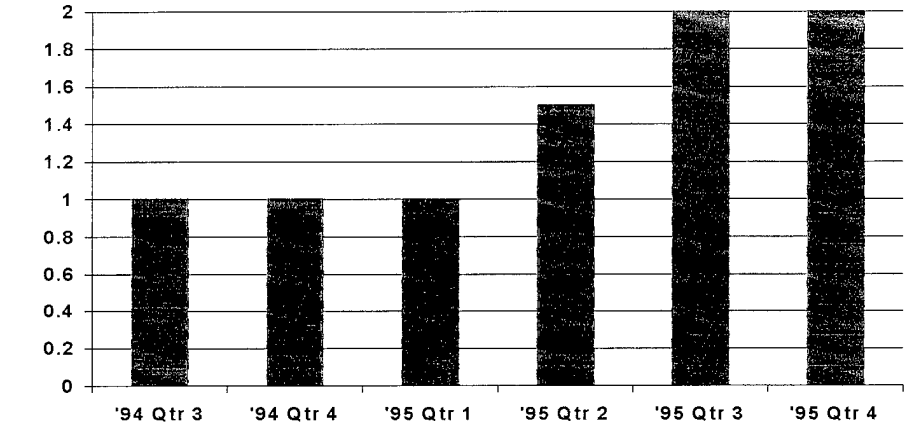



Stock Price Per Share
Ours
Closest Competitor
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
'94 Qtr 3
'94 Qtr 4
'95 Qtr 1
'95 Qtr 2
'95 Qtr 3
'95 Qtr 4
Our stock prices have declined over the period under consideration.
Disagree
Agree


Market Share
Ours
Closest Competitor
35%
30%
25%
20%
15%
10%
5%
0%
'94 Qtr 3
'94 Qtr 4
'95 Qtr 1
'95 Qtr 2
'95 Qtr 3
'95 Qtr 4
Our share of the market has been declining over the past three quarters.
Disagree
Agree

Cycle Time

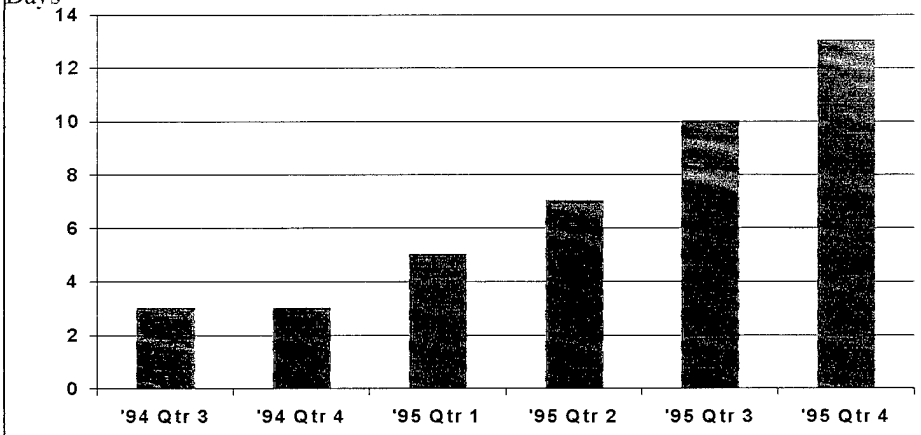
(Time from receipt of invoice to shipment).



Cycle time has decreased since '95 Qtr 1.

Disagree Agree

Inventory Turnover Time

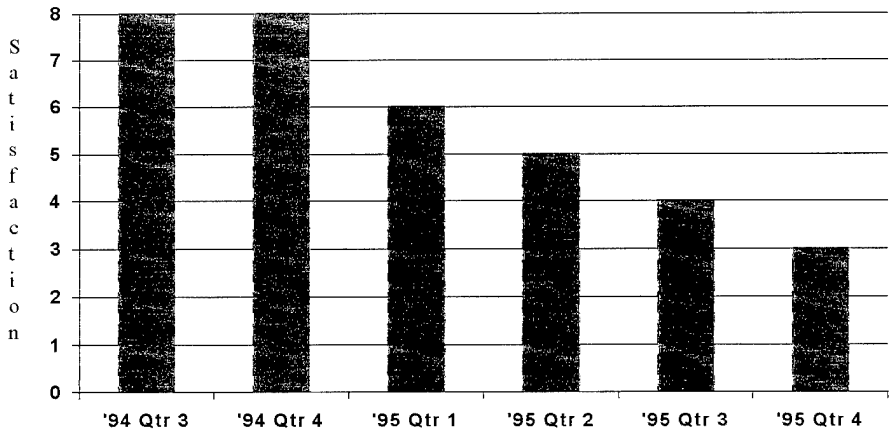


The time needed to go through 100% of stocked inventory is declining.

Disagree Agree

Distribution/Delivery Time
Customer Satisfaction

1= poor 10= excellent



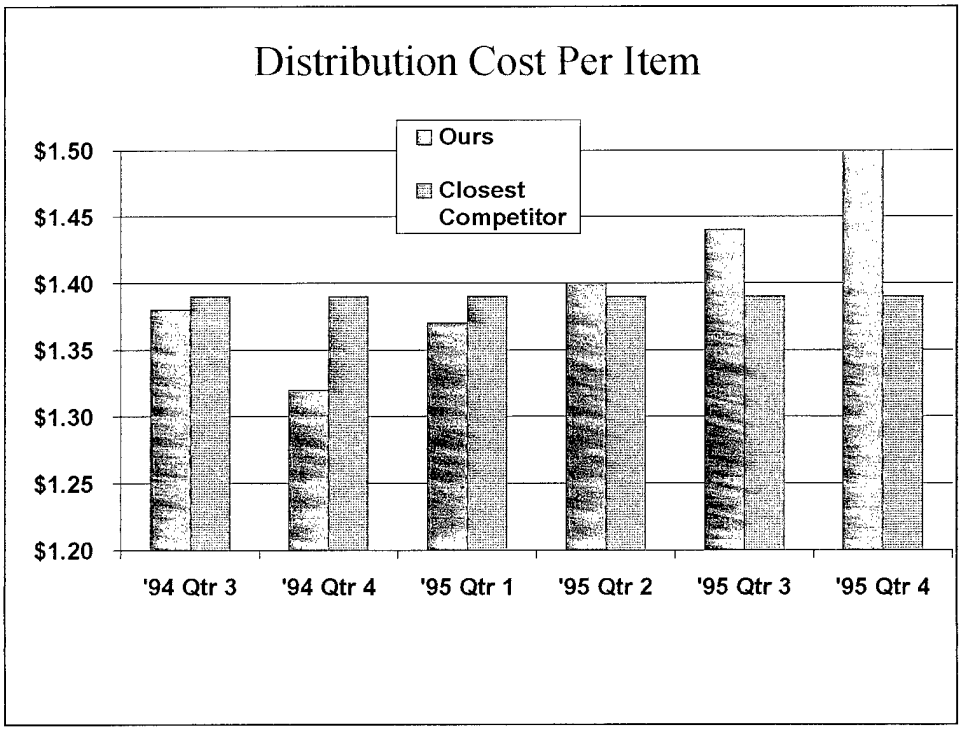
Customer satisfaction with distribution/delivery time has declined over the period being considered.

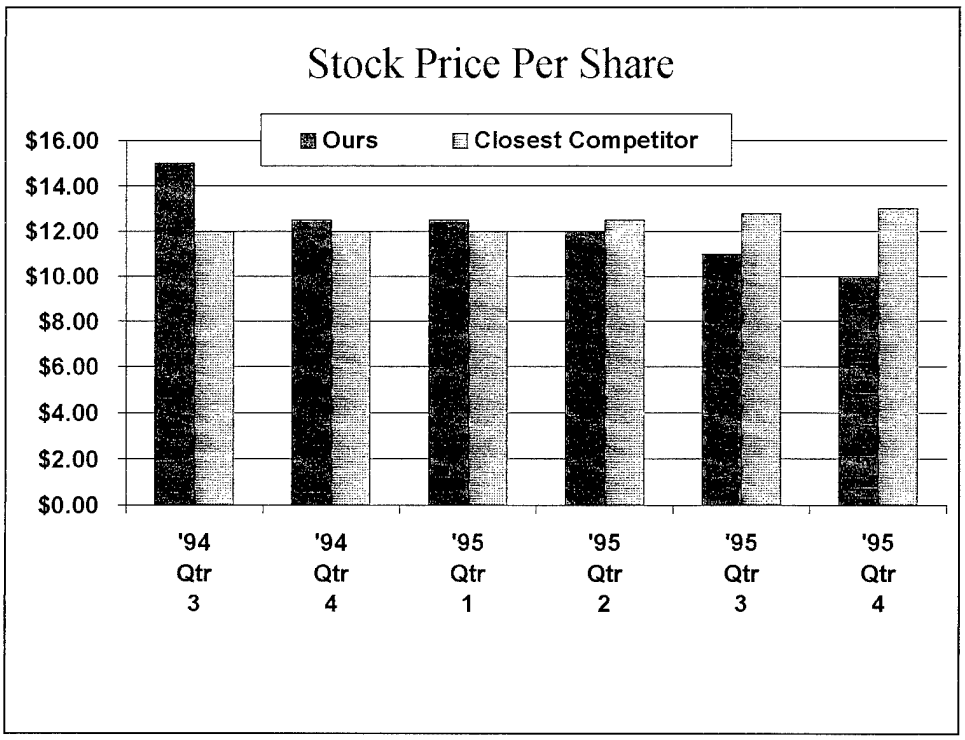
Disagree Agree

Based solely on the information provided, should the Distribution Process be evaluated against the world's benchmark distributor?

No Yes

Without changing any of your previous responses, you may review the six graphs. The graphs will be shown again in the same sequence as before. Again, please *do not* change any of your previous responses.




Stock Price Per Share
Ours
Closest Competitor
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
'94 Qtr 3
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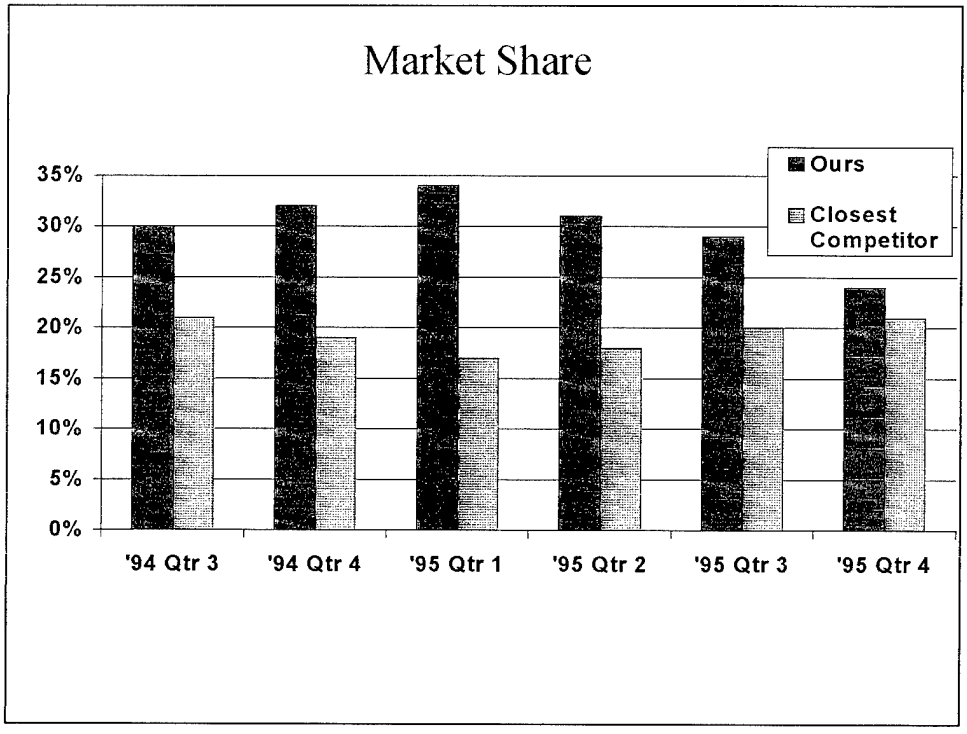
'95 Qtr 1
'95 Qtr 2
'95 Qtr 3
'95 Qtr 4


Market Share
Ours
Closest Competitor
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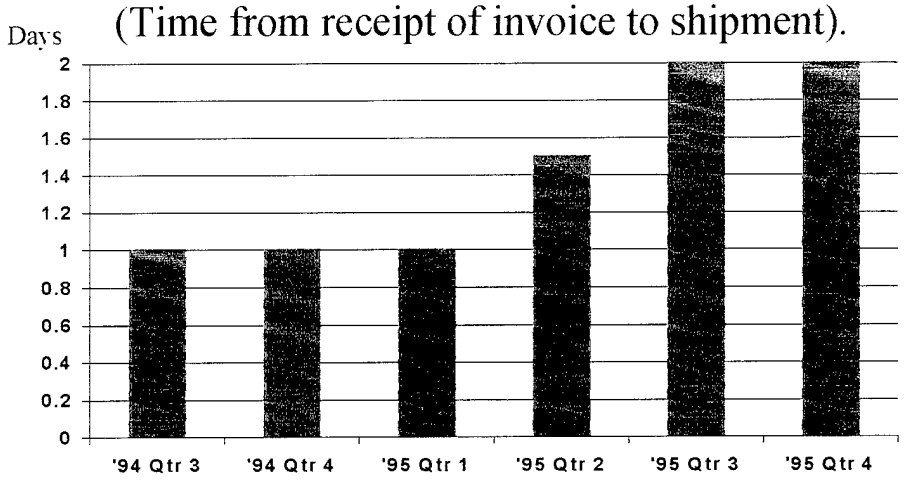
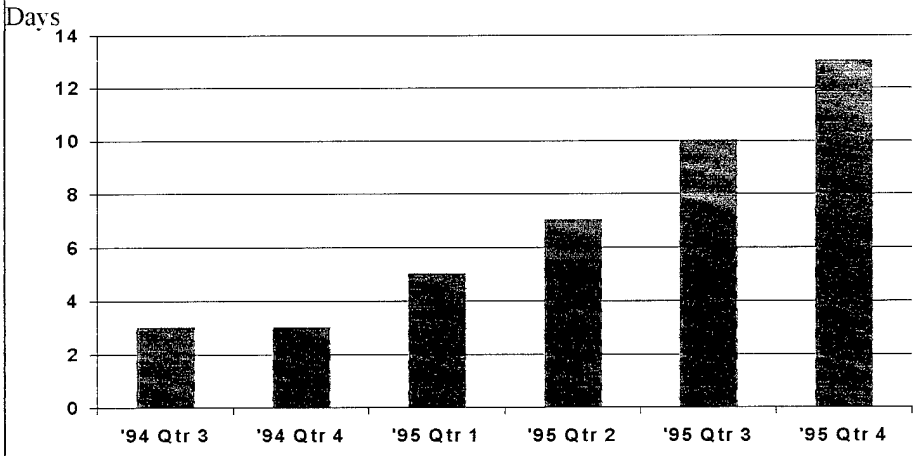
30%
25%
20%
15%
10%
5%
0%
'94 Qtr 3
'94 Qtr 4
'95 Qtr 1
'95 Qtr 2
'95 Qtr 3
'95 Qtr 4

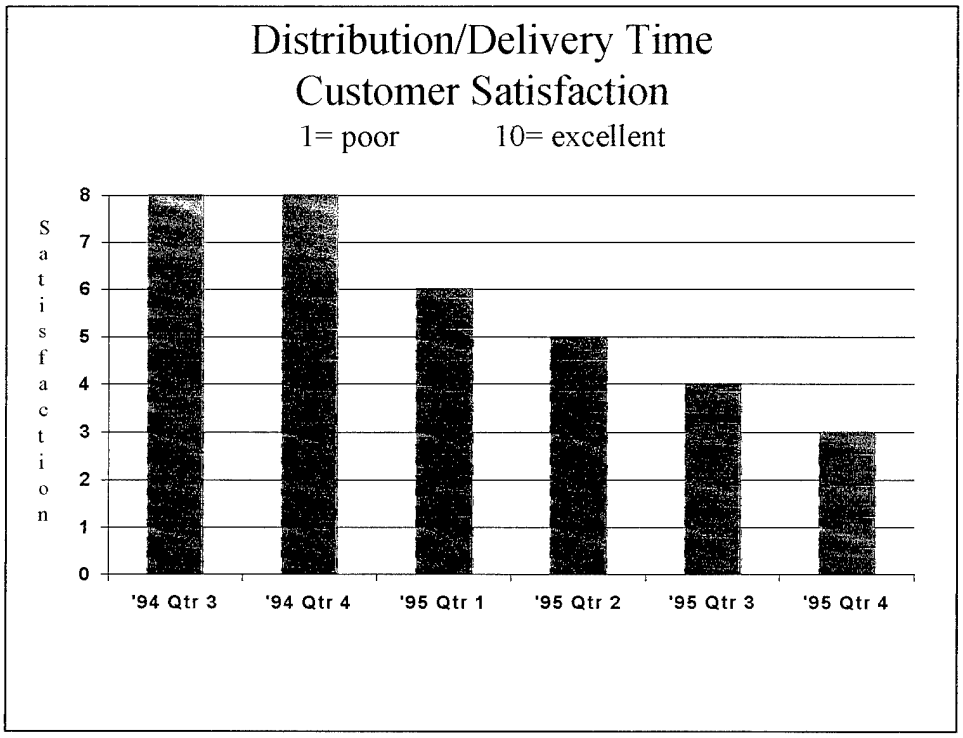
Cycle Time

(Time from receipt of invoice to shipment).



Inventory Turnover Time





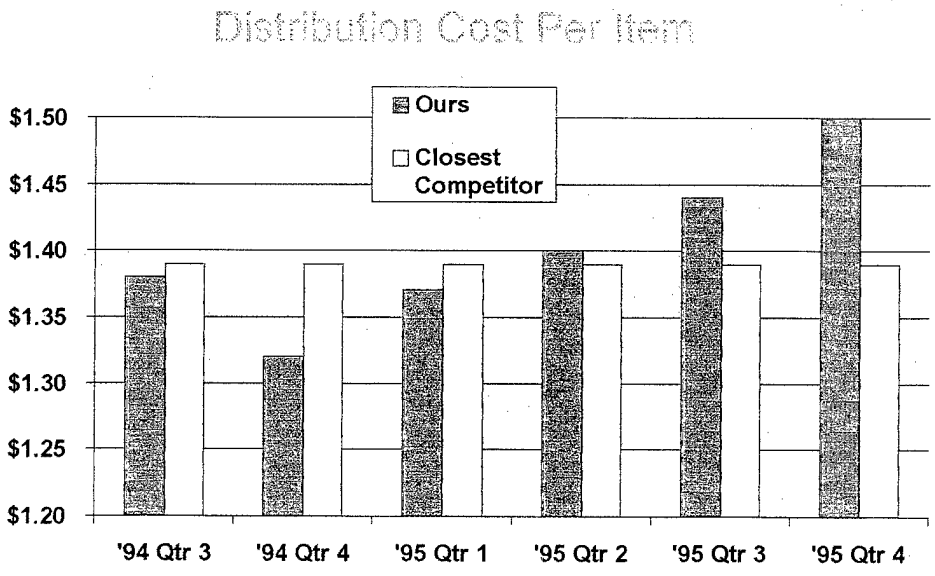
Based upon your review of the graphs, would you make the same decision?

No Yes

Please complete the attached survey and return the entire package.

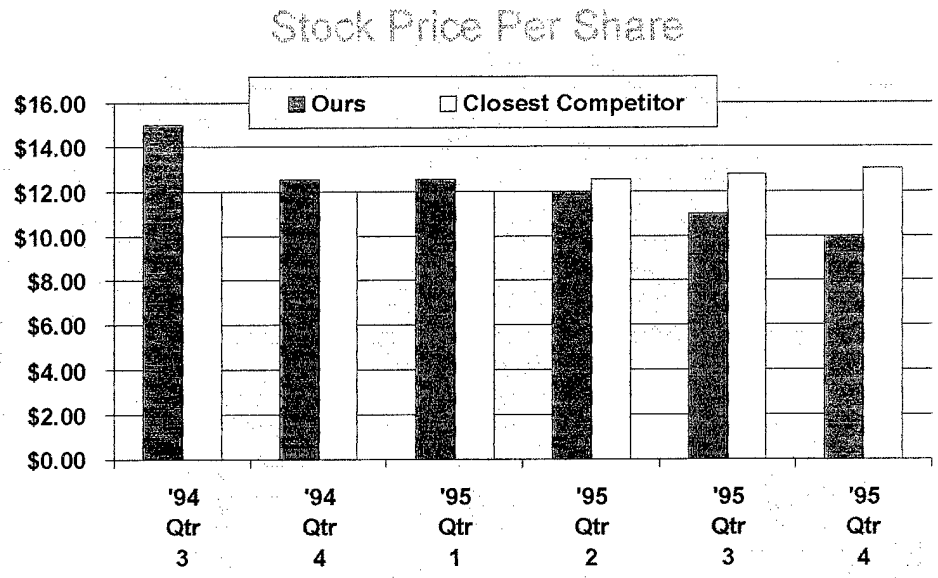
Thank you.

Benchmarking Decision



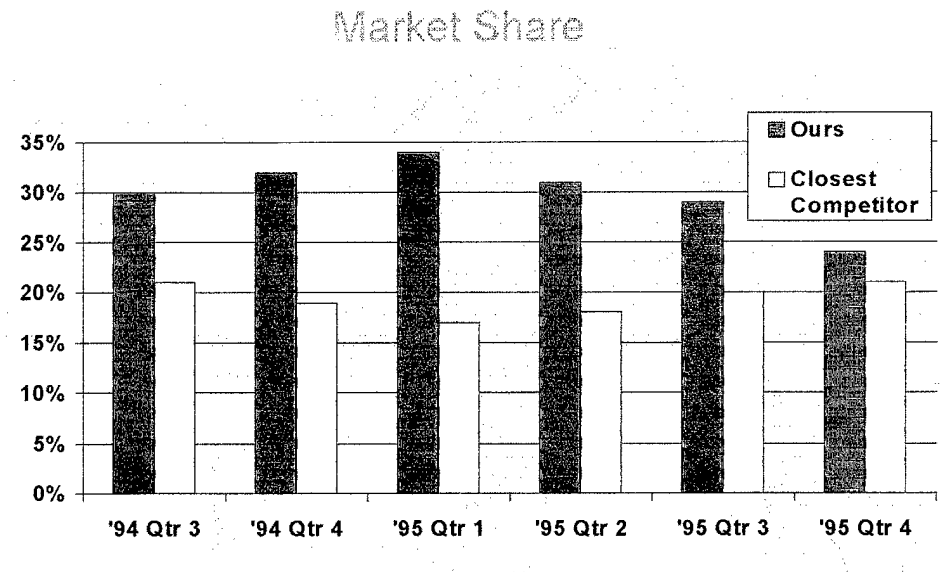
Our distribution cost per item has remained unchanged.

Disagree Agree



Our stock prices have declined over the period under consideration.

Disagree Agree

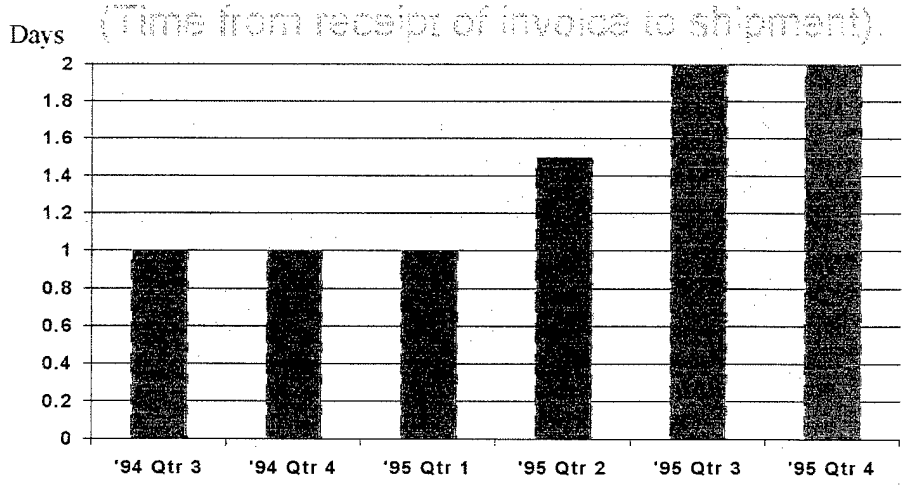


Our share of the market has been declining over the past three quarters.

Disagree Agree

Cycle Time

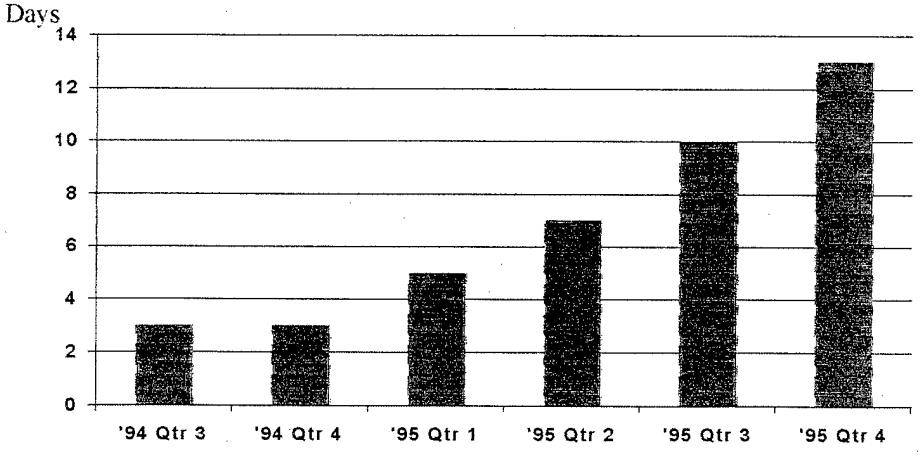
(Time from receipt of invoice to shipment)



Cycle time has decreased since '95 Qtr 1.

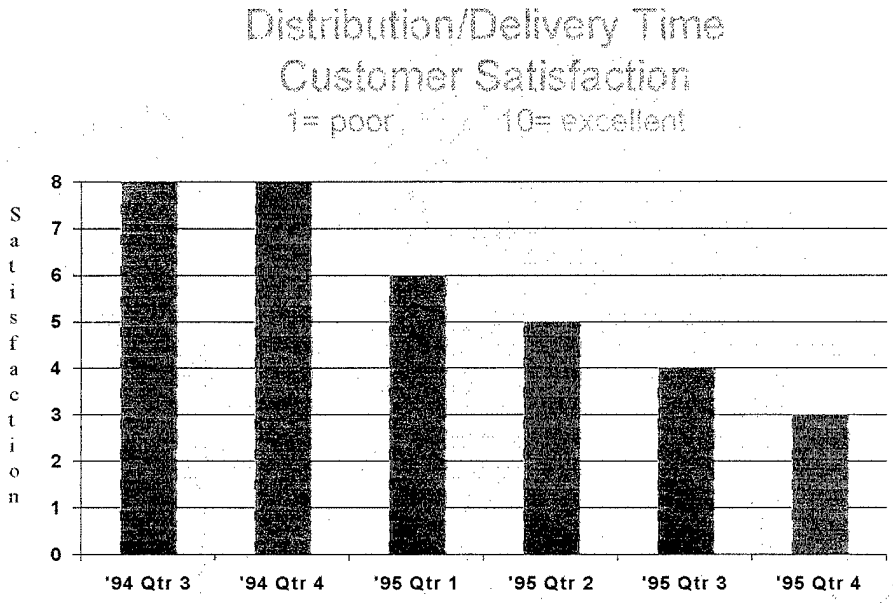
Disagree Agree

Inventory Turnover Time



The time needed to go through 100% of stocked inventory is declining.

Disagree Agree



Customer satisfaction with distribution/delivery time has declined over the period being considered.

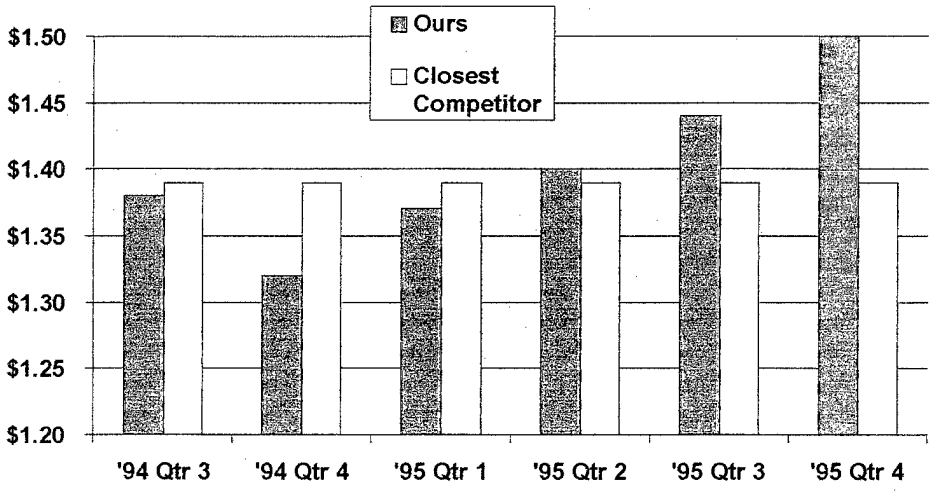
Disagree Agree

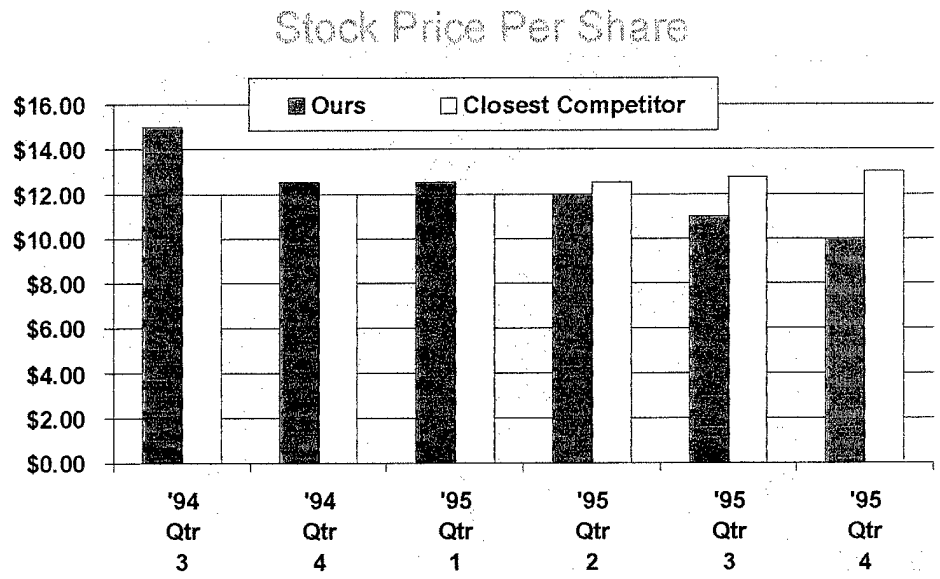
Based solely on the information provided, should the Distribution Process be evaluated against the world's benchmark distributor?

No Yes

Without changing any of your previous responses, you may review the six graphs. The graphs will be shown again in the same sequence as before. Again, please *do not* change any of your previous responses.

Distribution Cost Per Item




Stock Price Per Share
Ours
Closest Competitor
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
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$0.00
'94 Qtr 3
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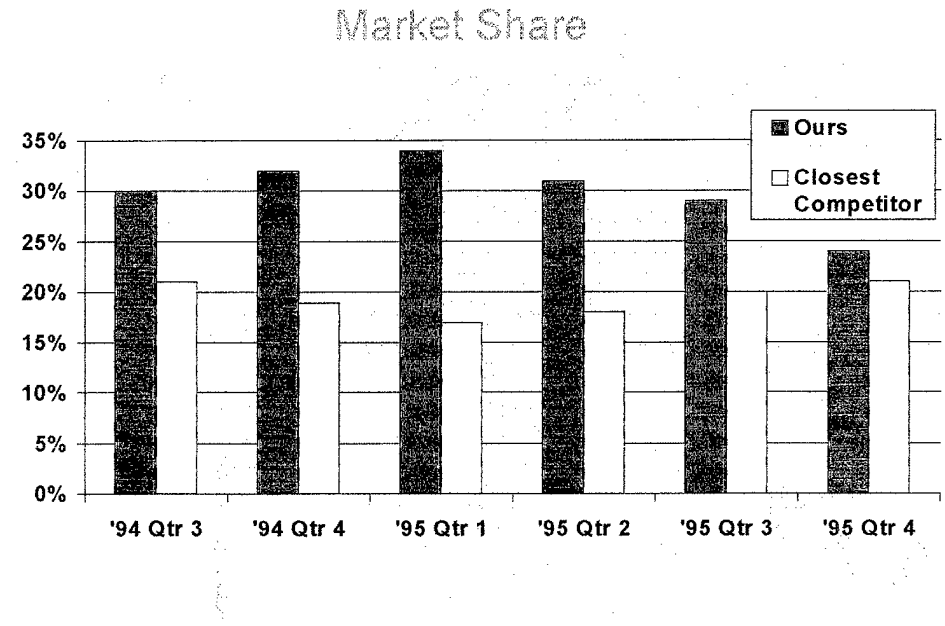
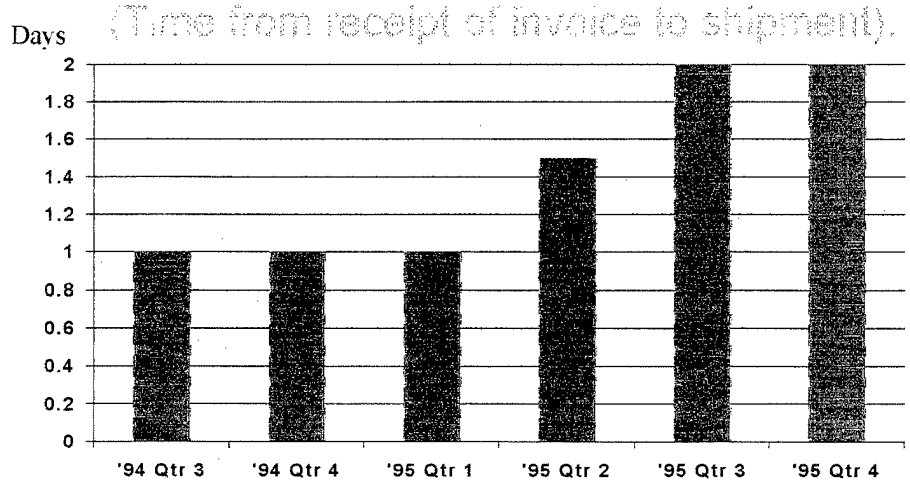
'95 Qtr 2
'95 Qtr 3
'95 Qtr 4

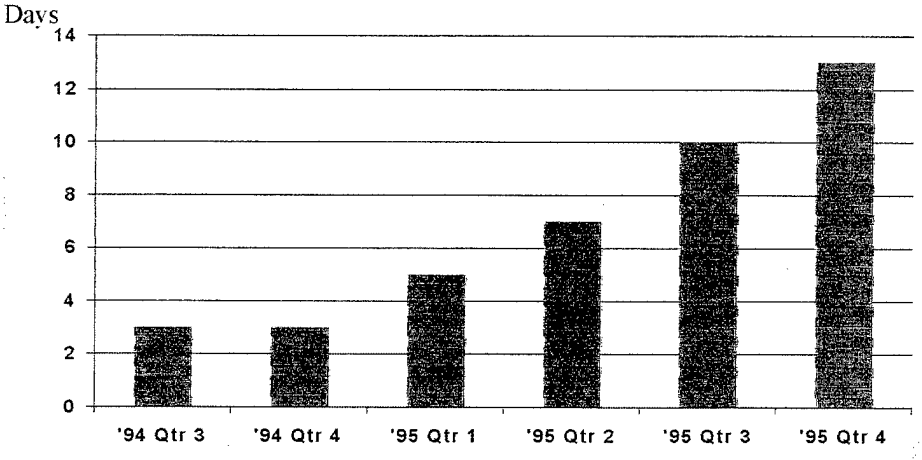

Market Share
Ours
Closest Competitor
35%
30%
25%
20%
15%
10%
5%
0%
'94 Qtr 3
'94 Qtr 4
'95 Qtr 1
'95 Qtr 2
'95 Qtr 3
'95 Qtr 4

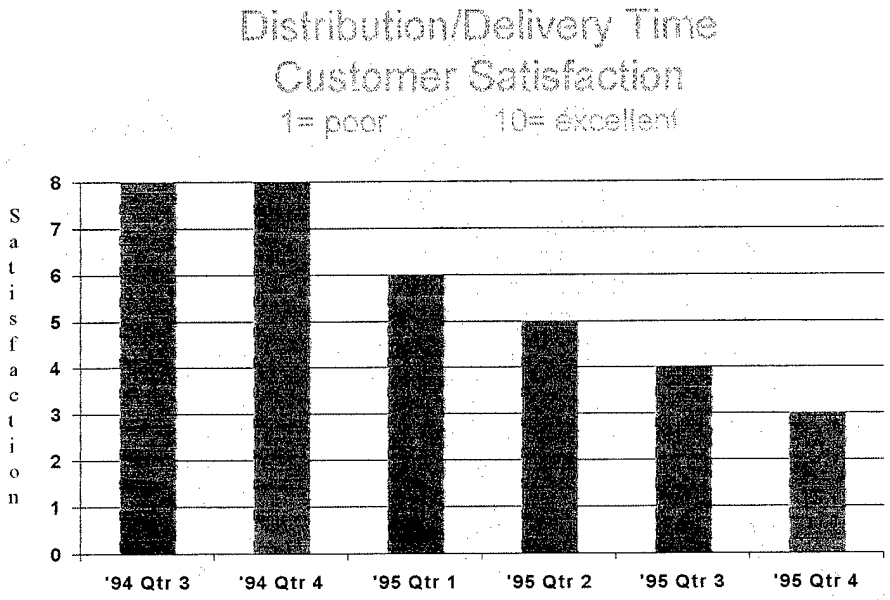
Cycle Time

(Time from receipt of invoice to shipment).



Inventory Turnover Time





Based upon your review of the graphs, would you make the same decision?

No Yes

Please complete the attached survey and return the entire package.

Thank you.

Outsourcing Decision

Decision Problem

You are the Chief Executive Officer (CEO) of a major metropolitan hospital. The board of regents has charged you with the task of determining whether the hospital should continue to operate its cafeteria. Based solely on the information contained in the following graphs, you must decide whether to maintain in-house operation of the cafeteria or contract out its function to a commercial food service contractor.

Currently, the cafeteria is run completely by the hospital in the hospital's facilities. If the cafeteria function were contracted out, all responsibilities for its operation would be assumed by the contractor. However, the location of the cafeteria would remain unchanged.

The first three graphs presented depict financial trends impacting your decision, while the final three show qualitative trends. Assume that these trends will continue if the hospital makes no changes. Your decision should be based solely on the information contained in the following six graphs. Do you contract out the hospital's food service function?

Decision Rules

Assuming that the six graphs that follow contain all the information necessary to make an informed decision, circle the printed response that corresponds to your answer for each of the graphs. Your response tasks are two fold: (1) For each slide, you will be asked to indicate disagreement or agreement with the slide's corresponding statement. Your response should indicate your disagreement or agreement with that particular graph. (2) At the end of the presentation, you will be asked to make an overall decision based on all the information presented. This decision should be based solely upon the six graphs. No information external to that presented in the graphs should be considered in any of your decision-making.

This is not a test and your name will not be recorded. However, this is a timed experiment. You will be given 20 seconds per graph to view each one and respond. The computer will automatically advance the slides you will be using to make your decisions.

There will be a statement at the bottom of each slide. The statement will also be on the answer sheet. **Please circle the response (disagree or agree) that corresponds to your response for each of the six slides and for your overall, final decision.**

The total length of this experiment should not exceed 10 minutes.

Stop!
Please, do not continue until instructed to do so.

Thank you in advance for your conscientious participation.

Answer Sheet

(Circle your responses)

In-house Net Costs vs. Contractor Bids

Disagree Agree 1) The contractor has underbid our costs every year.

Total Revenue vs. Total Costs

Disagree Agree 2) Total costs have exceeded total revenue for each of the past six years.

Profit and Loss (P&L)

Disagree Agree 3) The hospital food service has sustained increased losses over the past six years.

Hospital Cafeteria Customer Satisfaction

Disagree Agree 4) Customer satisfaction with hospital food service & quality declined each year over the period considered.

Contractor Reported Customer Satisfaction

Disagree Agree 5) Customer satisfaction with the contractor's food service & quality has consistently declined.

Percentage of Cafeteria Employees Retained
by the Contractor and the Hospital if the Food Service Function is Contracted Out

Disagree Agree 6) No employees would lose their jobs as a result of contracting out the food service operation.

Final Decision

Based solely on the information provided,
should the food service operation be contracted out?

No Yes

Without changing any of your previous responses, you may review the six graphs. The graphs will be shown again in the same sequence as before.

Again, please do not change any of your previous responses.

Reviewed Final Decision

Based upon your review of the graphs,
would you make the same decision?

No Yes

Please complete the following informational questionnaire and return the entire package.

Questionnaire

This questionnaire contains statements and questions that concern:
a) your background information for demographics,
b) your level of experience with graphs, and
c) the experiment just completed.

Please circle the most appropriate answer from the choices provided.

1. What is your gender? Female Male

2. What is your Education Level?

High School	Baccalaureate Degree	Doctoral Degree
Some College	Some Graduate Courses	
Associates Degree	Masters Degree	

3. Are you color blind? No Yes

4. Have you ever had any training with graph construction and/or interpretation?

(*Circle all that apply*).

a) Yes, formal training on graph construction.
b) Yes, formal training on graph interpretation.
c) Yes, informal training on graph construction.
d) Yes, informal training on graph interpretation.
e) No formal or informal training on graph construction or interpretation.

5. How often do you use graphs in decision-making?

Every day	Once a month	Never
Every other day	Once a quarter	
Once a week	Once a year	

6. How often do you see pictures on graphs (i.e. magazines, newspapers, briefings, etc.)?

Every day	Once a month	Never
Every other day	Once a quarter	
Once a week	Once a year	

7. Were the instructions clear and easy to follow? Comments:_____

No Yes

8. What was your level of interest in the experimental decision?

1 2 3 4 5 6 7
not interested very interested

9. The individual experimental questions (those on each graph) were easy to understand.

1 2 3 4 5 6 7
disagree agree

10. Based solely on the information provided, how confident are you that you made the appropriate overall, final decision?

1 2 3 4 5 6 7
not confident confident

11. Did you have any previous knowledge of this experiment?

No Yes

Thank you for participating in this experiment!

Benchmarking Decision

Decision Problem

You are the Chief Executive Officer (CEO) of a large industrial firm that produces and distributes ball bearings. Over the past six quarters (1 ½ years) it seems that something is wrong with the firm's distribution process. No one within the company can exactly identify the problem. Based solely on the information contained in the following graphs, you must decide whether to continue working the issue in-house or consult the world's most efficient distributor for assistance in evaluating/benchmarking your company's distribution process. Although this benchmark company doesn't deal in ball bearings, it should be able to identify and help correct the problem.

Currently, your distribution difficulties are suspected to be impacting the company's performance and competitiveness. Your closest competitor in the ball bearing business is gaining ground on your firm. Five of the following six graphs portray quantitative trends concerning the company's performance; three of the five depict the firm's competitiveness as compared with your company's closest competition. The final graph relates a qualitative trend. Assume that these trends will continue if the firm requests no assistance.

Although the benchmark in distribution operates in an entirely different business, it is reasonable to assume that this company can help identify your company's distribution troubles. This benchmark company, if consulted, is willing to help you evaluate your processes and aid in correcting your problems. The decision you're faced with is: do you ask this company to benchmark your process?

Decision Rules

Assuming that the six graphs that follow contain all the information necessary to make an informed decision, circle the printed response that corresponds to your answer for each of the graphs. Your response tasks are two fold: (1) For each slide, you will be asked to indicate disagreement or agreement with the slide's corresponding statement. Your response should indicate your disagreement or agreement with that particular graph. (2) At the end of the presentation, you will be asked to make an overall decision based on all the information presented. This decision should be based solely upon the six graphs. No information external to that presented in the graphs should be considered in any of your decision-making.

This is not a test and your name will not be recorded. However, this is a timed experiment. You will be given 20 seconds per graph to view each one and respond. The computer will automatically advance the slides you will be using to make your decisions.

There will be a statement at the bottom of each slide. The statement will also be on the answer sheet. **Please circle the response (disagree or agree) that corresponds to your response for each of the six slides and for your overall, final decision.**

The total length of this experiment should not exceed 10 minutes.

Stop!
Please, do not continue until instructed to do so.

Thank you in advance for your conscientious participation.

Answer Sheet

(Circle your responses)

Distribution Cost Per Item

Disagree Agree 1) Our distribution cost per item has remained unchanged.

Stock Price Per Share

Disagree Agree 2) Our stock prices have declined over the period under consideration.

Market Share

Disagree Agree 3) Our share of the market has been declining over the past three quarters.

Cycle Time

Disagree Agree 4) Cycle time has decreased since '95 Qtr 1.

Inventory Turnover Time

Disagree Agree 5) The time needed to go through 100% of stocked inventory is declining.

Distribution/Delivery Time Customer Satisfaction

Disagree Agree 6) Customer satisfaction with distribution/delivery has declined over the period being considered.

Final Decision

Based solely on the information provided,
should the distribution process be evaluated against the world's benchmark distributor?

No Yes

Without changing any of your previous responses, you may review the six graphs. The graphs will be shown again in the same sequence as before.

Again, please do not change any of your previous responses.

Reviewed Final Decision

Based upon your review of the graphs,
would you make the same decision?

No Yes

Please complete the attached informational questionnaire and return the entire package.

Questionnaire

This questionnaire contains statements and questions that concern:

a) your background information for demographics,
b) your level of experience with graphs, and
c) the experiment just completed.

Please circle the most appropriate answer from the choices provided.

1. What is your gender? Female Male

2. What is your Education Level?

High School	Baccalaureate Degree	Doctoral Degree
Some College	Some Graduate Courses	
Associates Degree	Masters Degree	

3. Are you color blind? No Yes

4. Have you ever had any training with graph construction and/or interpretation?

(*Circle all that apply*).

a) Yes, formal training on graph construction.
b) Yes, formal training on graph interpretation.
c) Yes, informal training on graph construction.
d) Yes, informal training on graph interpretation.
e) No formal or informal training on graph construction or interpretation.

5. How often do you use graphs in decision-making?

Every day	Once a month	Never
Every other day	Once a quarter	
Once a week	Once a year	

6. How often do you see pictures on graphs (i.e. magazines, newspapers, briefings, etc.)?

Every day	Once a month	Never
Every other day	Once a quarter	
Once a week	Once a year	

7. Were the instructions clear and easy to follow? Comments:_____

No Yes

8. What was your level of interest in the experimental decision?

1 2 3 4 5 6 7
not interested very interested

9. The individual experimental questions (those on each graph) were easy to understand.

1 2 3 4 5 6 7
disagree agree

10. Based solely on the information provided, how confident are you that you made the appropriate overall, final decision?

1 2 3 4 5 6 7
not confident confident

11. Did you have any previous knowledge of this experiment?

No Yes

Thank you for participating in this experiment!

Appendix F. Graph Creation Inputs

Outsourcing Decision							
		1990	1991	1992	1993	1994	1995
Graph 1	In-house	125.117	122.179	124.938	128.798	132.112	136.875
	Contractor	124.000	124.000	124.000	125.000	130.000	130.000
Graph 2	Revenue	705.550	680.000	750.000	773.000	797.000	821.250
	Costs	823.000	720.000	875.000	902.000	930.000	958.125
Graph 3		-118.000	-121.768	-125.000	-129.000	-133.000	-136.875
Graph 4		3.000	8.000	6.000	5.500	5.000	4.500
Graph 5		6.000	6.000	7.000	8.000	8.000	8.500
Graph 6		Contractor 90%		Hospital 10%		Total 100%	

	Outsourcing Decision Graphs	Benchmarking Decision Graphs
Graph 1 =	In-house Net Cost vs. Contractor Bids	Distribution Cost Per Item
Graph 2 =	Total Revenue vs. Total Costs	Stock Price Per Share
Graph 3 =	Profit and Loss (P&L)	Market Share
Graph 4 =	Hospital Cafeteria Customer Satisfaction	Cycle Time
Graph 5 =	Contractor Reported Customer Satisfaction	Inventory Turnover Time
Graph 6 =	Percentage of Cafeteria Employees Retained by the Contractor and the Hospital if the Food Service is Contracted Out	Distribution/Delivery Customer Satisfaction

Benchmarking Decision							
		1990	1991	1992	1993	1994	1995
Graph 1	Ours	1.38	1.32	1.37	1.40	1.44	1.50
	Competitor	1.39	1.39	1.39	1.39	1.39	1.39
Graph 2	Ours	15.00	12.50	12.50	12.00	11.00	10.00
	Competitor	12.00	12.00	12.00	12.50	12.75	13.00
Graph 3	Ours	30%	32%	34%	31%	29%	24%
	Competitor	21%	19%	17%	18%	20%	21%
Graph 4		1.00	1.00	1.00	1.50	2.00	2.00
Graph 5		3.00	3.00	5.00	7.00	10.00	13.00
Graph 6		8.00	8.00	6.00	5.00	4.00	3.00

Appendix G. Response Data

The four datasheets that make up this appendix contain the responses obtained from this study's experiments. "S1-S6" represent responses to the statements on the six graphs used in the decision process. "Q1-Q12" correspond to the post test questionnaire responses. "D", "R", and "C" are the decision reached by the subject, the reviewed decision, and an indication of consistency between the previous two, respectively.

Control Group Charts: Outsourcing											Demographics										
Obs	S1	S2	S3	S4	S5	S6	Total	D	R	C	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
1	0	0	0	0	0	0	0	0	1	1	1	5	0	0	3	4	0	4	3	3	0
2	0	0	0	1	0	1	2	0	1	1	1	4	0	3	1	3	0	6	5	6	0
3	0	0	0	0	0	0	0	1	1	0	1	2	0	0	0	3	0	7	7	1	0
4	0	0	0	0	0	0	0	0	0	0	0	6	0	2	4	6	0	4	5	4	0
5	0	0	0	0	0	0	0	0	0	0	0	5	0	7	3	6	0	4	6	7	0
6	0	0	0	0	0	0	0	1	1	0	1	5	0	1	2	4	0	4	6	7	0
7	0	0	0	0	0	0	0	0	1	1	1	6	0	1	1	3	0	4	6	3	0
8	0	0	0	0	0	0	0	0	0	0	0	5	0	7	0	4	0	1	5	7	0
9	0	0	0	0	0	0	0	1	1	0	0	4	0	3	2	6	0	5	6	7	0
10	0	0	0	0	0	1	1	0	0	0	1	2	0	1	1	3	0	4	6	6	0
11	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	1	0	4	7	7	0
12	1	0	0	0	0	0	1	0	0	0	0	5	0	1	3	6	0	6	6	5	0
13	0	0	0	1	0	0	1	0	0	0	0	3	0	3	0	3	0	3	5	5	0
14	0	0	0	0	0	1	1	1	1	0	0	5	0	7	3	6	0	7	7	2	0
15	0	.	0	0	0	1	1	0	0	0	1	6	0	3	3	6	0	5	5	5	0
16	1	0	0	0	0	0	1	0	0	0	0	2	0	2	4	6	0	6	4	6	0
17	0	0	0	1	0	0	1	0	0	0	1	2	0	0	0	2	0	4	6	5	0
18	0	0	0	1	0	1	2	0	0	0	1	3	0	2	2	4	0	5	6	5	0
19	1	0	0	1	0	0	2	0	0	0	1	4	0	7	0	2	0	5	7	7	0
20	0	0	0	1	1	1	3	0	0	0	0	6	0	3	5	6	1	2	5	6	0
21	1	0	0	0	0	1	2	0	0	0	1	4	0	0	0	2	0	1	3	7	0
22	1	.	0	0	0	1	2	0	0	0	0	3	0	0	0	4	0	6	5	6	0
23	0	0	0	0	0	1	1	0	0	0	0	6	0	10	2	4	0	5	6	5	0
24	1	0	0	0	0	0	1	0	1	1	1	4	0	2	1	3	0	6	6	5	0
25	0	0	0	0	0	1	1	1	1	0	1	4	0	3	2	4	0	5	7	1	0
26	0	0	0	0	0	1	1	0	0	0	1	4	0	3	1	3	0	6	5	6	0
27	1	0	0	1	0	1	3	0	0	0	1	6	0	3	0	3	0	5	4	5	0
28	1	0	0	0	0	1	2	0	0	0	1	4	0	0	1	6	0	4	7	7	0
29	0	0	0	1	0	0	1	0	0	0	0	6	0	0	0	3	0	6	4	5	0
Total	8	0	0	8	1	14	31	5	9	4											

Experimental Group Charts: Outsourcing											Demographics											
Obs	S1	S2	S3	S4	S5	S6	Total	D	R	C	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
1	0	0	1	1	1	1	4	0	1	1	0	2	1	4	2	6	0	5	4	6	5	0
2	0	0	0	0	0	1	1	0	0	0	0	4	0	7	4	5	0	5	4	6	4	0
3	1	0	0	0	0	0	1	0	0	0	0	6	0	1	3	4	0	1	7	7	1	0
4	1	0	0	1	0	1	3	0	0	0	0	2	0	0	1	3	0	6	6	7	3	0
5	0	0	1	1	0	1	3	1	0	1	0	4	0	4	1	5	0	2	5	6	1	0
6	1	0	0	1	0	0	2	1	0	1	0	6	0	2	0	2	0	7	7	4	1	0
7	1	1	0	0	0	1	3	1	1	0	1	6	0	7	6	5	0	6	4	5	2	0
8	1	0	0	1	1	.	3	.	.	0	0	6	0	1	2	4	0	4	7	5	6	0
9	1	1	1	1	0	1	5	1	1	0	0	5	0	4	2	2	0	5	5	6	4	0
10	1	0	0	0	0	1	2	1	1	0	1	4	0	1	3	3	0	4	4	2	4	0
11	0	0	0	0	0	1	1	0	0	0	0	7	0	3	4	6	0	6	6	5	4	0
12	.	.	.	.	.	.	0	.	.	0	1	4	0	0	0	3	1	1	1	1	1	0
13	1	0	0	1	0	1	3	1	1	0	0	2	0	0	1	3	1	2	2	1	7	0
14	.	.	.	.	.	.	0	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.
15	0	0	0	0	0	1	1	0	0	0	0	4	0	0	2	2	0	6	6	7	2	0
16	0	0	0	0	0	0	0	0	0	0	0	4	0	2	4	6	0	6	6	6	6	0
17	0	0	0	0	1	0	1	1	0	1	1	2	0	3	1	3	0	4	6	2	3	0
18	0	0	0	0	0	1	1	0	0	0	0	6	0	0	4	4	0	5	5	7	1	0
19	0	1	0	1	0	0	2	0	0	0	1	6	0	3	4	4	0	6	7	6	1	0
20	0	1	0	0	0	1	2	0	0	0	0	4	0	2	3	4	0	6	4	6	6	0
21	1	0	0	1	0	1	3	0	0	0	0	4	0	4	4	3	0	4	3	3	7	0
22	0	0	0	0	0	0	0	0	0	0	0	6	0	4	3	5	0	4	6	6	2	0
23	0	0	0	0	0	1	1	0	0	0	1	2	0	7	2	3	0	7	7	6	1	0
24	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	3	0	5	6	6	2	0
25	0	0	0	0	0	1	1	0	0	0	0	4	0	7	1	4	0	6	7	7	2	0
26	1	0	0	1	0	1	3	1	0	1	0	6	0	7	0	0	0	4	5	3	6	0
27	0	0	0	0	0	1	1	0	0	0	0	5	0	0	0	4	0	6	6	6	4	0
28	0	0	0	1	0	1	2	0	0	0	1	6	0	0	2	4	0	2	5	6	1	0
29	1	0	.	1	0	1	3	0	0	0	0	6	0	1	2	4	0	6	6	5	3	0
30	0	0	0	0	0	0	0	0	.	.	0	4	0	0	2	3	0	6	5	6	2	0
31	1	0	0	1	0	0		0	0	0	1	6	0	7	3	4	0	6	5	7	7	0
Total	12	4	3	13	3	19	52	8	5	5												

Control Group Charts: Benchmarking											Demographics										
Obs	S1	S2	S3	S4	S5	S6	Total	D	R	C	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	6	0	5	5	4	0
2	1	0	1	0	1	0	3	1	1	0	1	2	0	0	2	2	0	5	5	4	0
3	0	0	1	0	1	0	2	0	0	0	1	1	0	0	0	2	0	4	4	1	0
4	1	0	0	0	0	0	1	0	0	0	0	4	0	3	3	0	0	4	3	4	0
5	1	1	1	0	0	1	4	1	1	0	0	3	0	3	0	5	0	3	4	4	0
6	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	6	0	5	5	6	0
7	0	0	0	0	1	0	1	0	0	0	1	1	0	0	2	4	0	5	3	6	0
8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	6	0	7	6	7	0
9	0	0	0	0	0	0	0	0	0	0	0	4	0	10	3	4	0	7	6	7	0
10	0	0	1	0	0	1	2	1	0	1	0	2	0	0	1	4	0	5	5	4	0
11	0	0	0	0	0	0	0	0	0	0	1	6	0	1	2	6	0	6	7	7	0
12	1	0	1	0	0	0	2	0	0	0	1	4	0	1	1	6	0	1	4	4	0
13	0	0	1	0	0	1	2	1	1	0	0	7	0	10	4	5	0	7	5	6	0
14	0	0	0	0	0	1	1	0	0	0	0	1	0	0	3	3	0	5	5	6	0
15	1	0	0	1	0	0	2	0	1	1	0	3	0	0	1	3	0	2	2	2	0
16	0	0	1	0	0	1	2	0	0	0	1	3	0	6	2	3	0	4	7	7	0
17	0	1	0	0	0	0	1	.	.	0	0	2	0	0	0	3	0	4	4	5	0
18	0	1	1	0	0	0	2	0	0	0	0	6	0	10	3	4	0	7	7	4	0
19	0	0	0	0	0	0	0	0	0	0	0	6	0	3	1	3	0	6	6	6	0
20	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	3	0	7	7	7	0
21	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	2	0	7	7	7	0
22	0	0	1	0	0	0	1	0	0	0	0	2	0	7	3	4	0	5	6	7	0
23	0	0	1	0	0	0	1	.	.	0	1	2	0	0	0	2	0	6	7	7	0
24	0	0	1	0	0	0	1	0	0	0	1	3	0	0	1	3	0	6	7	6	0
25	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	1	0	4	7	7	0
26	0	0	0	0	0	0	0	0	0	0	1	2	0	3	0	5	0	4	6	6	0
27	0	0	0	0	0	0	0	0	0	0	0	6	0	1	1	3	0	7	7	6	0
28	0	1	0	1	0	0	2	0	0	0	1	1	1	0	0	1	1	.	.	.	0
29	0	0	1	1	0	0	2	0	0	0	1	2	0	4	6	6	1	4	4	4	0
30	0	0	1	0	0	0	1	0	0	0	1	2	0	0	0	2	0	4	4	4	0
31	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4	0	5	5	5	0
32	0	0	0	0	0	0	0	0	0	0	0	6	0	7	4	6	0	7	7	7	0
33	0	0	0	0	0	0	0	0	0	0	1	6	0	3	1	6	0	5	5	7	0
34	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4	0	4	6	5	0
35	0	0	0	0	1	0	1	0	0	0	1	4	0	0	1	5	0	5	7	5	0
36	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	0	5	6	7	0

Obs	S1	S2	S3	S4	S5	S6	Total	D	R	C	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
37	0	0	0	.	0	0	0	0	0	0	1	2	0	0	1	5	0	6	5	5	0
38	1	1	1	0	1	0	4	0	0	0	0	1	0	0	0	4	0	1	1	1	0
39	0	0	0	0	0	0	0	0	0	0	0	4	0	7	0	3	0	3	6	6	0
40	0	0	1	0	0	0	1	0	0	0	0	2	0	0	0	4	0	7	7	6	0
41	0	0	1	0	0	0	1	1	0	1	0	2	0	0	4	6	0	5	6	5	0
Total	6	5	16	3	5	5	40	5	4	3											

Experimental Group Charts: Benchmarking											Demographics											
Obs	S1	S2	S3	S4	S5	S6	Total	D	R	C	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
1	0	0	0	0	0	0	0	1	1	0	1	4	0	0	0	3	0	4	4	4	3	0
2	0	0	1	0	0	0	1	0	1	1	1	4	0	2	0	3	0	3	4	3	5	0
3	0	0	0	0	0	0	0	0	0	0	0	4	0	10	6	3	0	7	7	7	1	0
4	1	0	0	1	0	0	2	1	1	0	1	3	0	0	2	3	0	4	6	6	2	0
5	1	0	0	1	0	0	2	0	0	0	1	2	0	0	0	0	0	2	2	1	3	0
6	0	0	0	1	0	0	1	0	0	0	1	4	0	0	0	3	0	5	5	5	3	0
7	0	1	1	0	1	0	3	0	0	0	1	5	0	4	0	4	0	3	3	3	1	0
8	0	0	0	0	0	0	0	0	0	0	1	5	0	3	1	3	0	4	7	7	1	0
9	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	0	5	6	4	4	0
10	0	1	0	0	0	0	1	0	0	0	0	2	0	0	0	2	0	7	7	5	1	0
11	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	3	0	6	5	4	4	0
12	0	0	0	0	0	0	0	0	0	0	0	4	0	7	0	4	0	7	7	7	1	0
13	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	4	0	6	6	7	2	0
14	0	0	0	0	0	0	0	0	0	0	1	4	0	7	0	2	0	4	5	5	2	0
15	1	1	0	0	0	0	2	1	0	1	1	2	0	0	0	3	0	5	5	5	4	0
16	0	0	1	0	0	0	1	0	0	0	1	2	0	1	0	3	0	5	6	6	2	0
17	0	0	0	0	0	0	0	0	0	0	0	2	0	5	.	4	0	4	5	4	4	0
18	0	0	0	0	0	0	0	0	0	0	1	4	0	1	1	2	0	6	6	6	1	0
19	0	0	0	0	0	0	0	0	0	0	0	6	0	7	1	6	0	7	7	7	6	0
20	0	0	0	0	0	0	0	0	0	0	0	5	0	7	2	4	0	4	5	5	5	0
21	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	2	0	5	7	6	1	0
22	0	0	0	1	0	0	1	0	0	0	0	4	0	3	3	5	0	4	4	4	4	0
23	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	2	0	4	5	5	2	0
24	1	0	0	1	1	0	3	0	0	0	0	3	0	3	3	4	0	6	6	6	2	0
25	1	1	0	1	0	0	3	0	0	0	0	4	0	0	0	0	0	6	6	5	4	0
26	0	0	0	0	0	0	0	0	0	0	1	2	0	2	0	4	0	6	6	6	1	0
27	1	0	1	0	1	0	3	0	0	0	0	5	1	2	2	5	0	5	3	4	4	0
28	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	2	0	4	4	5	3	0
29	0	0	0	0	0	0	0	0	0	0	0	4	0	7	2	6	0	5	5	5	2	0
30	0	0	0	0	0	0	0	0	0	0	1	4	0	3	2	5	1	3	5	6	4	0
31	0	0	0	0	0	0	0	0	1	1	0	4	0	3	4	3	0	4	4	6	3	0
32	0	0	0	0	0	0	0	0	1	1	1	4	0	0	0	4	0	6	7	4	2	0
33	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	6	0	5	6	6	4	0
34	0	0	0	0	0	0	0	0	0	0	0	4	0	10	6	6	0	4	7	7	1	0
35	0	0	0	1	0	0	1	0	0	0	1	2	0	2	0	3	1	4	3	4	4	0
36	1	1	1	0	0	0	3	1	1	0	0	6	0	0	1	2	0	3	6	5	6	0

Obs	S1	S2	S3	S4	S5	S6	Total	D	R	C	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
37	0	0	0	0	0	0	0	0	0	0	1	4	0	0	3	5	0	4	4	5	2	0
38	1	0	0	0	0	0	1	0	1	1	1	2	0	0	0	0	.	3	3	3	3	0
39	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	4	0	5	7	7	1	0
40	0	1	1	1	1	0	4	0	0	0	0	3	0	0	0	4	1	2	2	3	2	0
41	0	0	0	0	0	0	0	0	0	0	0	6	0	0	4	4	0	4	5	5	3	0
42	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	4	0	6	5	6	3	0
43	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	6	0	3	6	7	7	0
44	0	0	0	0	0	0	0	0	0	0	0	4	0	3	3	5	0	5	4	5	3	0
45	0	0	0	0	0	0	0	.	.	.	0	4	0	0	0	6	0	1	7	7	1	0
46	0	0	1	0	0	0	1	0	0	0	0	4	0	0	1	6	0	7	7	6	1	0
Total	8	6	7	8	4	0	33	4	7	5												

Appendix H. Format for Importing Outsourcing Data Into Statgraphics

The datasheet that makes up this appendix contains the responses obtained from this study's experiments. This data is a transposition, in part, of that in Appendix G. This format was necessary to facilitate the use of Statgraphics. The outsourcing decision problem had 60 subjects.

"DP" represents the decision problem and was categorized as "0" for outsourcing and "1" for benchmarking; compare Appendices H and I. "GP" represents the group with "C" indicating the control and "E" the experimental group. "S1-S6" represent the responses to the statements on the six graphs used in the decision process. "Q1-Q12" correspond to the post test questionnaire responses. "D," "R," and "C" are the decision reached by the subject, the reviewed decision, and an indication of consistency between the previous two, respectively.

Obs	DP	GP	S1	S2	S3	S4	S5	S6	D	R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
1	0	C	0	0	0	0	0	0	0	1	1	5	0	0	3	4	0	4	3	3	0	
2	0	C	0	0	0	1	0	1	0	1	1	4	0	3	1	3	0	6	5	6	0	
3	0	C	0	0	0	0	0	0	1	1	1	2	0	0	0	3	0	7	7	1	0	
4	0	C	0	0	0	0	0	0	0	0	0	6	0	2	4	6	0	4	5	4	0	
5	0	C	0	0	0	0	0	0	0	0	0	5	0	7	3	6	0	4	6	7	0	
6	0	C	0	0	0	0	0	0	1	1	1	5	0	1	2	4	0	4	6	7	0	
7	0	C	0	0	0	0	0	0	0	1	1	6	0	1	1	3	0	4	6	3	0	
8	0	C	0	0	0	0	0	0	0	0	0	5	0	7	0	4	0	1	5	7	0	
9	0	C	0	0	0	0	0	0	1	1	0	4	0	3	2	6	0	5	6	7	0	
10	0	C	0	0	0	0	0	1	0	0	1	2	0	1	1	3	0	4	6	6	0	
11	0	C	0	0	0	0	0	1	0	0	0	2	0	0	0	1	0	4	7	7	0	
12	0	C	1	0	0	0	0	0	0	0	0	5	0	1	3	6	0	6	6	5	0	
13	0	C	0	0	0	1	0	0	0	0	0	3	0	3	0	3	0	3	5	5	0	
14	0	C	0	0	0	0	0	1	1	1	0	5	0	7	3	6	0	7	7	2	0	
15	0	C	0	.	0	0	0	1	0	0	1	6	0	3	3	6	0	5	5	5	0	
16	0	C	1	0	0	0	0	0	0	0	0	2	0	2	4	6	0	6	4	6	0	
17	0	C	0	0	0	1	0	0	0	0	1	2	0	0	0	2	0	4	6	5	0	
18	0	C	0	0	0	1	0	1	0	0	1	3	0	2	2	4	0	5	6	5	0	
19	0	C	1	0	0	1	0	0	0	0	1	4	0	7	0	2	0	5	7	7	0	
20	0	C	0	0	0	1	1	1	0	0	0	6	0	3	5	6	1	2	5	6	0	
21	0	C	1	0	0	0	0	1	0	0	1	4	0	0	0	2	0	1	3	7	0	
22	0	C	1	.	0	0	0	1	0	0	0	3	0	0	0	4	0	6	5	6	0	
23	0	C	0	0	0	0	0	1	0	0	0	6	0	10	2	4	0	5	6	5	0	
24	0	C	1	0	0	0	0	0	0	1	1	4	0	2	1	3	0	6	6	5	0	
25	0	C	0	0	0	0	0	1	1	1	1	4	0	3	2	4	0	5	7	1	0	
26	0	C	0	0	0	0	0	1	0	0	1	4	0	3	1	3	0	6	5	6	0	

Obs	DP	GP	S1	S2	S3	S4	S5	S6	D	R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
27	0	C	1	0	0	1	0	1	0	0	1	6	0	3	0	3	0	5	4	5	0	
28	0	C	1	0	0	0	0	1	0	0	1	4	0	0	1	6	0	4	7	7	0	
29	0	C	0	0	0	1	0	0	0	0	0	6	0	0	0	3	0	6	4	5	0	
30	0	E	0	0	1	1	1	1	0	1	0	2	1	4	2	6	0	5	4	6	5	0
31	0	E	0	0	0	0	0	1	0	0	0	4	0	7	4	5	0	5	4	6	4	0
32	0	E	1	0	0	0	0	0	0	0	0	6	0	1	3	4	0	1	7	7	1	0
33	0	E	1	0	0	1	0	1	0	0	0	2	0	0	1	3	0	6	6	7	3	0
34	0	E	0	0	1	1	0	1	1	0	0	4	0	4	1	5	0	2	5	6	1	0
35	0	E	1	0	0	1	0	0	1	0	0	6	0	2	0	2	0	7	7	4	1	0
36	0	E	1	1	0	0	0	1	1	1	1	6	0	7	6	5	0	6	4	5	2	0
37	0	E	1	0	0	1	1	.	.	.	0	6	0	1	2	4	0	4	7	5	6	0
38	0	E	1	1	1	1	0	1	1	1	0	5	0	4	2	2	0	5	5	6	4	0
39	0	E	1	0	0	0	0	1	1	1	1	4	0	1	3	3	0	4	4	2	4	0
40	0	E	0	0	0	0	0	1	0	0	0	7	0	3	4	6	0	6	6	5	4	0
41	0	E	.	.	.	.	.	.	.	.	1	4	0	0	0	3	1	1	1	1	1	0
42	0	E	1	0	0	1	0	1	1	1	0	2	0	0	1	3	1	2	2	1	7	0
43	0	E	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
44	0	E	0	0	0	0	0	1	0	0	0	4	0	0	2	2	0	6	6	7	2	0
45	0	E	0	0	0	0	0	0	0	0	0	4	0	2	4	6	0	6	6	6	6	0
46	0	E	0	0	0	0	1	0	1	0	1	2	0	3	1	3	0	4	6	2	3	0
47	0	E	0	0	0	0	0	1	0	0	0	6	0	0	4	4	0	5	5	7	1	0
48	0	E	0	1	0	1	0	0	0	0	1	6	0	3	4	4	0	6	7	6	1	0
49	0	E	0	1	0	0	0	1	0	0	0	4	0	2	3	4	0	6	4	6	6	0
50	0	E	1	0	0	1	0	1	0	0	0	4	0	4	4	3	0	4	3	3	7	0
51	0	E	0	0	0	0	0	0	0	0	0	6	0	4	3	5	0	4	6	6	2	0
52	0	E	0	0	0	0	0	1	0	0	1	2	0	7	2	3	0	7	7	6	1	0
53	0	E	0	0	0	0	0	0	0	0	0	2	0	0	2	3	0	5	6	6	2	0
54	0	E	0	0	0	0	0	1	0	0	0	4	0	7	1	4	0	6	7	7	2	0
55	0	E	1	0	0	1	0	1	1	0	0	6	0	7	0	0	0	4	5	3	6	0
56	0	E	0	0	0	0	0	1	0	0	0	5	0	0	0	4	0	6	6	6	4	0
57	0	E	0	0	0	1	0	1	0	0	1	6	0	0	2	4	0	2	5	6	1	0
58	0	E	1	0	.	1	0	1	0	0	0	6	0	1	2	4	0	6	6	5	3	0
59	0	E	0	0	0	0	0	0	0	.	0	4	0	0	2	3	0	6	5	6	2	0
60	0	E	1	0	0	1	0	0	0	0	1	6	0	7	3	4	0	6	5	7	7	0

Appendix I. Format for Importing Benchmarking Data Into Statgraphics

The datasheet that makes up this appendix contains the responses obtained from this study's experiments. This data is a transposition, in part, of that in Appendix G. This format was necessary to facilitate the use of Statgraphics. The benchmarking decision problem had 87 subjects.

"DP" represents the decision problem and was categorized as "0" for outsourcing and "1" for benchmarking. Compare Appendices H and I. "GP" represents the group with "C" indicating the control and "E" the experimental group. "S1-S6" represent the responses to the statements on the six graphs used in the decision process. "Q1-Q12" correspond to the post test questionnaire responses. "D", "R", and "C" are the decision reached by the subject, the reviewed decision, and an indication of consistency between the previous two, respectively.

Obs	DP	GP	S1	S2	S3	S4	S5	S6	D	R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
1	1	C	0	0	0	0	0	0	0	0	0	3	0	0	2	6	0	5	5	4	0	
2	1	C	1	0	1	0	1	0	1	1	1	2	0	0	2	2	0	5	5	4	0	
3	1	C	0	0	1	0	1	0	0	0	1	1	0	0	0	2	0	4	4	1	0	
4	1	C	1	0	0	0	0	0	0	0	0	4	0	3	3	0	0	4	3	4	0	
5	1	C	1	1	1	0	0	1	1	1	0	3	0	3	0	5	0	3	4	4	0	
6	1	C	0	0	0	0	0	0	0	0	0	4	0	0	0	6	0	5	5	6	0	
7	1	C	0	0	0	0	1	0	0	0	1	1	0	0	2	4	0	5	3	6	0	
8	1	C	0	0	0	0	0	0	0	0	0	1	0	0	3	6	0	7	6	7	0	
9	1	C	0	0	0	0	0	0	0	0	0	4	0	10	3	4	0	7	6	7	0	
10	1	C	0	0	1	0	0	1	1	0	0	2	0	0	1	4	0	5	5	4	0	
11	1	C	0	0	0	0	0	0	0	0	1	6	0	1	2	6	0	6	7	7	0	
12	1	C	1	0	1	0	0	0	0	0	1	4	0	1	1	6	0	1	4	4	0	
13	1	C	0	0	1	0	0	1	1	1	0	7	0	10	4	5	0	7	5	6	0	
14	1	C	0	0	0	0	0	1	0	0	0	1	0	0	3	3	0	5	5	6	0	
15	1	C	1	0	0	1	0	0	0	1	0	3	0	0	1	3	0	2	2	2	0	
16	1	C	0	0	1	0	0	1	0	0	1	3	0	6	2	3	0	4	7	7	0	
17	1	C	0	1	0	0	0	0	.	.	0	2	0	0	0	3	0	4	4	5	0	
18	1	C	0	1	1	0	0	0	0	0	0	6	0	10	3	4	0	7	7	4	0	
19	1	C	0	0	0	0	0	0	0	0	0	6	0	3	1	3	0	6	6	6	0	
20	1	C	0	0	0	0	0	0	0	0	0	2	0	0	3	3	0	7	7	7	0	
21	1	C	0	0	0	0	0	0	0	0	0	1	0	2	0	2	0	7	7	7	0	
22	1	C	0	0	1	0	0	0	0	0	0	2	0	7	3	4	0	5	6	7	0	
23	1	C	0	0	1	0	0	0	.	.	1	2	0	0	0	2	0	6	7	7	0	
24	1	C	0	0	1	0	0	0	0	0	1	3	0	0	1	3	0	6	7	6	0	
25	1	C	0	0	0	0	0	0	0	0	1	2	0	0	1	1	0	4	7	7	0	
26	1	C	0	0	0	0	0	0	0	0	1	2	0	3	0	5	0	4	6	6	0	

Obs	DP	GP	S1	S2	S3	S4	S5	S6	D	R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
27	1	C	0	0	0	0	0	0	0	0	0	6	0	1	1	3	0	7	7	6	0	
28	1	C	0	1	0	1	0	0	0	0	1	1	1	0	0	1	1	.	.	.	0	
29	1	C	0	0	1	1	0	0	0	0	1	2	0	4	6	6	1	4	4	4	0	
30	1	C	0	0	1	0	0	0	0	0	1	2	0	0	0	2	0	4	4	4	0	
31	1	C	0	0	0	0	0	0	0	0	0	3	0	0	0	4	0	5	5	5	0	
32	1	C	0	0	0	0	0	0	0	0	0	6	0	7	4	6	0	7	7	7	0	
33	1	C	0	0	0	0	0	0	0	0	1	6	0	3	1	6	0	5	5	7	0	
34	1	C	0	0	0	0	0	0	0	0	1	1	0	0	0	4	0	4	6	5	0	
35	1	C	0	0	0	0	1	0	0	0	1	4	0	0	1	5	0	5	7	5	0	
36	1	C	0	0	0	0	0	0	0	0	0	2	0	0	0	4	0	5	6	7	0	
37	1	C	0	0	0	.	0	0	0	0	1	2	0	0	1	5	0	6	5	5	0	
38	1	C	1	1	1	0	1	0	0	0	0	1	0	0	0	4	0	1	1	1	0	
39	1	C	0	0	0	0	0	0	0	0	0	4	0	7	0	3	0	3	6	6	0	
40	1	C	0	0	1	0	0	0	0	0	0	2	0	0	0	4	0	7	7	6	0	
41	1	C	0	0	1	0	0	0	1	0	0	2	0	0	4	6	0	5	6	5	0	
42	1	E	0	0	0	0	0	0	1	1	1	4	0	0	0	3	0	4	4	4	3	0
43	1	E	0	0	1	0	0	0	0	1	1	4	0	2	0	3	0	3	4	3	5	0
44	1	E	0	0	0	0	0	0	0	0	0	4	0	10	6	3	0	7	7	7	1	0
45	1	E	1	0	0	1	0	0	1	1	1	3	0	0	2	3	0	4	6	6	2	0
46	1	E	1	0	0	1	0	0	0	0	1	2	0	0	0	0	0	2	2	1	3	0
47	1	E	0	0	0	1	0	0	0	0	1	4	0	0	0	3	0	5	5	5	3	0
48	1	E	0	1	1	0	1	0	0	0	1	5	0	4	0	4	0	3	3	3	1	0
49	1	E	0	0	0	0	0	0	0	0	1	5	0	3	1	3	0	4	7	7	1	0
50	1	E	0	0	0	0	0	0	0	0	0	4	0	0	0	2	0	5	6	4	4	0
51	1	E	0	1	0	0	0	0	0	0	0	2	0	0	0	2	0	7	7	5	1	0
52	1	E	0	0	0	0	0	0	0	0	1	2	0	0	0	3	0	6	5	4	4	0
53	1	E	0	0	0	0	0	0	0	0	0	4	0	7	0	4	0	7	7	7	1	0
54	1	E	0	0	0	0	0	0	0	0	0	6	0	0	0	4	0	6	6	7	2	0
55	1	E	0	0	0	0	0	0	0	0	1	4	0	7	0	2	0	4	5	5	2	0
56	1	E	1	1	0	0	0	0	1	0	1	2	0	0	0	3	0	5	5	5	4	0
57	1	E	0	0	1	0	0	0	0	0	1	2	0	1	0	3	0	5	6	6	2	0
58	1	E	0	0	0	0	0	0	0	0	0	2	0	5	.	4	0	4	5	4	4	0
59	1	E	0	0	0	0	0	0	0	0	1	4	0	1	1	2	0	6	6	6	1	0
60	1	E	0	0	0	0	0	0	0	0	0	6	0	7	1	6	0	7	7	7	6	0
61	1	E	0	0	0	0	0	0	0	0	0	5	0	7	2	4	0	4	5	5	5	0
62	1	E	0	0	0	0	0	0	0	0	1	4	0	0	0	2	0	5	7	6	1	0
63	1	E	0	0	0	1	0	0	0	0	0	4	0	3	3	5	0	4	4	4	4	0
64	1	E	0	0	0	0	0	0	0	0	1	2	0	0	1	2	0	4	5	5	2	0

65	1	E	1	0	0	1	1	0	0	0	0	3	0	3	3	4	0	6	6	6	2	0
Obs	DP	GP	S1	S2	S3	S4	S5	S6	D	R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
66	1	E	1	1	0	1	0	0	0	0	0	4	0	0	0	0	0	6	6	5	4	0
67	1	E	0	0	0	0	0	0	0	0	1	2	0	2	0	4	0	6	6	6	1	0
68	1	E	1	0	1	0	1	0	0	0	0	5	1	2	2	5	0	5	3	4	4	0
69	1	E	0	0	0	0	0	0	0	0	1	5	0	0	0	2	0	4	4	5	3	0
70	1	E	0	0	0	0	0	0	0	0	0	4	0	7	2	6	0	5	5	5	2	0
71	1	E	0	0	0	0	0	0	0	0	1	4	0	3	2	5	1	3	5	6	4	0
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73	1	E	0	0	0	0	0	0	0	1	1	4	0	0	0	4	0	6	7	4	2	0
74	1	E	0	0	0	0	0	0	0	0	0	2	0	0	0	6	0	5	6	6	4	0
75	1	E	0	0	0	0	0	0	0	0	0	4	0	10	6	6	0	4	7	7	1	0
76	1	E	0	0	0	1	0	0	0	0	1	2	0	2	0	3	1	4	3	4	4	0
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84	1	E	0	0	0	0	0	0	0	0	0	6	0	2	0	6	0	3	6	7	7	0
85	1	E	0	0	0	0	0	0	0	0	0	4	0	3	3	5	0	5	4	5	3	0
86	1	E	0	0	0	0	0	0	.	.	0	4	0	0	0	6	0	1	7	7	1	0
87	1	E	0	0	1	0	0	0	0	0	0	4	0	0	1	6	0	7	7	6	1	0

Appendix J. Statgraphics Output

Outsourcing Decision Problem

Kruskal-Wallis analysis of Confidence by Group

Level	Sample Size	Average Rank
C	29	29.6034
E	30	30.3833

Test statistic = 0.0322734 Significance level = 0.857429

Kruskal-Wallis analysis of Decision by Group

Level	Sample Size	Average Rank
C	29	27.4138
E	28	30.6429

Test statistic = 1.0205 Significance level = 0.312401

Kruskal-Wallis analysis of Decision by Gender

Level	Sample Size	Average Rank
0	34	28.3676
1	23	29.9348

Test statistic = 0.231485 Significance level = 0.630425

Kruskal-Wallis analysis of Decision by Training

Level	Sample Size	Average Rank
0	16	26.0625
1	7	30.6429
2	7	26.5714
3	11	30.2727
4	5	33.9000
7	10	31.0500
10	1	22.5000

Test statistic = 2.88818 Significance level = 0.822745

Kruskal-Wallis analysis of Confidence by Gender

Level	Sample Size	Average Rank
0	35	32.3714
1	24	26.5417

Test statistic = 1.74119 Significance level = 0.186988

Kruskal-Wallis analysis of Confidence by Training

Level	Sample Size	Average Rank
0	17	32.4706
1	8	27.0625
2	7	24.7143
3	11	25.9091
4	5	30.7000
7	10	37.0000
10	1	20.0000

Test statistic = 4.11991 Significance level = 0.660453

Kruskal-Wallis analysis of Outsourcing Graph 1 by Group

Level	Sample Size	Average Rank
C	29	27.5000
E	29	31.5000

Test statistic = 1.2 Significance level = 0.273322

Kruskal-Wallis analysis of Outsourcing Graph 2 by Group

Level	Sample Size	Average Rank
C	27	26.5000
E	29	30.3621

Test statistic = 3.93899 Significance level = 0.047179

Kruskal-Wallis analysis of Outsourcing Graph 3 by Group

Level	Sample Size	Average Rank
C	29	27.5000
E	28	30.5536

Test statistic = 3.22222 Significance level = 0.0726449

Kruskal-Wallis analysis of Outsourcing Graph 4 by Group

Level	Sample Size	Average Rank
C	29	27.0000
E	29	32.0000

Test statistic = 1.83398 Significance level = 0.175659

Kruskal-Wallis analysis of Outsourcing Graph 5 by Group

Level	Sample Size	Average Rank
C	29	28.5000
E	29	30.5000

Test statistic = 1.05556 Significance level = 0.304231

Kruskal-Wallis analysis of Outsourcing Graph 6 by Group

Level	Sample Size	Average Rank
C	29	26.2586
E	28	31.8393

Test statistic = 2.20141 Significance level = 0.137885

Kruskal-Wallis analysis of Reviewed Decision by Group

Level	Sample Size	Average Rank
C	29	29.4138
E	28	28.5714

Test statistic = 0.091954 Significance level = 0.761708

Kruskal-Wallis analysis of Reviewed Decision by Gender

Level	Sample Size	Average Rank
0	34	27.8529
1	23	30.6957

Test statistic = 1.00853 Significance level = 0.315256

Kruskal-Wallis analysis of Reviewed Decision by Training

Level	Sample Size	Average Rank
0	16	28.0625
1	7	32.6429
2	7	24.5000
3	11	29.6818
4	5	30.2000
7	10	30.2000
10	1	24.5000

Test statistic = 2.68965 Significance level = 0.846669

Benchmarking Decision Problem

Kruskal-Wallis analysis of Confidence by Group

Level	Sample Size	Average Rank
C	40	45.8250
E	46	41.4783

Test statistic = 0.680786 Significance level = 0.409316

Kruskal-Wallis analysis of Decision by Group

Level	Sample Size	Average Rank
C	39	43.3846
E	45	41.7333

Test statistic = 0.333576 Significance level = 0.563561

Kruskal-Wallis analysis of Decision by Gender

Level	Sample Size	Average Rank
0	46	42.5652
1	38	42.4211

Test statistic = 2.53242E-3 Significance level = 0.959865

Kruskal-Wallis analysis of Decision by Training

Level	Sample Size	Average Rank
0	45	44.5333
1	5	38.0000
2	6	38.0000
3	11	41.8182
4	2	38.0000
5	1	38.0000
6	1	38.0000
7	8	38.0000
10	5	46.4000

Test statistic = 4.29178 Significance level = 0.829885

Kruskal-Wallis analysis of Confidence by Gender

Level	Sample Size	Average Rank
0	48	47.0938
1	38	38.9605

Test statistic = 2.36274 Significance level = 0.124264

Kruskal-Wallis analysis of Confidence by Training

Level	Sample Size	Average Rank
0	47	39.1915
1	5	51.6000
2	6	41.2500
3	11	46.6364
4	2	11.7500
5	1	17.0000
6	1	76.0000
7	8	58.0000
10	5	60.0000

Test statistic = 13.737 Significance level = 0.0888819

Kruskal-Wallis analysis of Benchmarking Graph 1 by Group

Level	Sample Size	Average Rank
C	41	43.3659
E	46	44.5652

Test statistic = 0.120646 Significance level = 0.728335

Kruskal-Wallis analysis of Benchmarking Graph 2 by Group

Level	Sample Size	Average Rank
C	41	43.8049
E	46	44.1739

Test statistic = 0.0139634 Significance level = 0.905936

Kruskal-Wallis analysis of Benchmarking Graph 3 by Group

Level	Sample Size	Average Rank
C	41	49.4756
E	46	39.1196

Test statistic = 6.24513 Significance level = 0.0124535

Kruskal-Wallis analysis of Benchmarking Graph 4 by Group

Level	Sample Size	Average Rank
C	40	41.2250
E	46	45.4783

Test statistic = 1.85477 Significance level = 0.17323

Kruskal-Wallis analysis of Benchmarking Graph 5 by Group

Level	Sample Size	Average Rank
C	41	44.8049
E	46	43.2826

Test statistic = 0.282949 Significance level = 0.594775

Kruskal-Wallis analysis of Benchmarking Graph 6 by Group

Level	Sample Size	Average Rank
C	41	46.8049
E	46	41.5000

Test statistic = 5.8834 Significance level = 0.0152843

Kruskal-Wallis analysis of Reviewed Decision by Group

Level	Sample Size	Average Rank
C	39	42.7308
E	45	42.3000

Test statistic = 0.0327416 Significance level = 0.85641

Kruskal-Wallis analysis of Reviewed Decision by Gender

Level	Sample Size	Average Rank
0	46	42.2391
1	38	42.8158

Test statistic = 0.0584404 Significance level = 0.808978

Kruskal-Wallis analysis of Reviewed Decision by Training

Level	Sample Size	Average Rank
0	45	43.2333
1	5	39.5000
2	6	39.5000
3	11	43.3182
4	2	39.5000
5	1	39.5000
6	1	39.5000
7	8	39.5000
10	5	47.9000

Test statistic = 3.24605 Significance level = 0.917981

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Vita

Lt. David L. Peeler, Jr. earned a Bachelor of Arts degree in Political Science from Berea College in Berea, Kentucky in 1988. He also earned a Bachelor of Science degree with double majors in Mathematics and Economics from Troy State University in Troy, Alabama in 1990. Lt. Peeler received his commission through Officer's Training School (OTS) in 1992. Following OTS, he was assigned to the 43rd Air Refueling Wing at Malmstrom AFB, Montana. He served as Chief of the Financial Services Flight in the 43rd Comptroller Squadron and subsequently in the 341st Missile Wing, following the base's re-host from Air Mobility Command (AMC) to Air Force Space Command (AFSPC). While serving in the position of Chief of Financial Services, Lt. Peeler was selected as HQ AFSPC's Financial Services Officer of the Year for fiscal year 1994 and was named the 341st Missile Wing's Company Grade Officer of the Year for 1994. Upon graduation from the Air Force Institute of Technology, Lt. Peeler will be assigned to Hanscom AFB, Massachusetts.

Permanent Addresses: 16 Meadow Oaks Drive
Surfside Beach, S.C. 29575
and
Chandler Creek Road
Mars Hill, N.C. 28754

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13. ABSTRACT (*Maximum 200 Words*)

This thesis investigated the influence, if any, of background graphics on the decision-making process. Specifically the hypotheses tested the affect of background graphics on a decision-makers accuracy and confidence. A literature review revealed an abundance of graphic research but little reference to the use of background graphics. Using guidelines previously created for high-integrity graphics, a timed 2 x 2 factorial experimental design was developed to compare the responses to both traditional graphics and those treated with background graphics. One hundred forty-seven subjects, all employees of the United States Air Force or defense contractors were involved in the experiments. The Kruskal-Wallis test was employed to test the hypotheses. The analysis of the test results indicate that background graphics neither affect decision accuracy nor the confidence a decision-maker places in a decision. It was also determined that gender and training have no affect on accuracy and confidence.

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